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EXPANSION OF STEAM IN THE STEAM-ENGINE.

An Investigation of the Experiments made with the Screw Machinery of the French Naval Steamer CHER *to Determine the Economic Efficiencies of Different Measures of Expansion for Steam.*

By Chief Engineer ISHERWOOD, U. S. Navy.

[Continued from Vol. lxxvi, page 12.]

Before commencing an experiment, the engine was worked for one hour under the intended conditions, so that it might be in proper harmony with them when the experiment began. At the end of an experiment great care was taken to leave the water in the boilers at exactly the same level as at the commencement, and under the same steam pressure. The sacks of coal were delivered on the fire-room floor as required.

One experiment was made each day, but there is nothing in the original data to show how long it continued; probably the experiments averaged about four hours each. This is too short a time to give the coal consumption with the accuracy necessary for the purpose,

although the closest attention was given to have the fires in the same condition and of the same thickness at the beginning and end of an experiment, for it is evident that as the estimation had to be made by the eye, considerable inaccuracy was unavoidable, and that the shorter the time among which the error was to be divided, the greater it became. This was not the case, however, with the feed-water measurement, which may be depended on as very exact, and as it alone is taken for the measure of the cost of the power in the different experiments, the coal expenditure is of use only as giving the economic vaporization by the boiler.

It is regretable that the details and data of these experiments were not more fully given, and particularly that the experiments were not of longer duration. With such short experiments, the indicator diagrams, instead of being taken half hourly, should have been taken every five minutes, and the data should have included as measured from them not only the quantities given in the table, but a number of others; such, for example, as the pressure of the steam in the cylinder at the commencement of the stroke of the pistons, at the point of cutting off the steam, and at the end of the stroke of the pistons. The back pressure against the piston of the middle cylinder should have been given as well as that against the pistons of the end cylinders which is given. The temperatures of the engine room, fire room, atmosphere, sea water and feed water, should have been given as well as the height of the barometer. The weight of refuse from the coal should have been noted also.

Notwithstanding these omitted quantities, which were desirable for many purposes besides those that the experimenters had immediately in view, the experiments are of great value, being on the most important facts in steam engineering, namely, the relative economic efficiencies of different measures of expansion for steam; and although they are not comparable for completeness, extent and variety to the writer's prior ones on the same subject, and although they add nothing new to his discoveries, yet they are of consequence—and therein lies their true importance—as confirmatory of the accuracy of his facts and the correctness of his deductions, and none the less so, as having been made by foreign engineers of the highest reputation, far removed from the interested and partisan efforts which assailed the unwelcome truth here.

Discussion of the Experiments.

The first point to investigate is the accuracy of the experiments according to their own evidence. They were made in a very large enclosed basin, free from tidal influence; and the vessel occupied the same position throughout. Under these conditions, the same development of power should give the same number of revolutions to the screw in equal time; and with unequal revolutions in equal time, the *net* power should be in the ratio of the cubes of those revolutions. The first postulate is self-evident, and the second has been proved experimentally true by a vast number of trials in a great variety of circumstances.

In experiment A, 66·34 revolutions of the screw per minute required 448·758 net horses-power, while in experiment O, 66·27 revolutions of the screw per minute required 462·756 net horses-power, a discrepancy of $\left(\frac{462{\cdot}756 - \overline{448{\cdot}758 \div 1{\cdot}003} \times 100}{462{\cdot}756} =\right)$ 3·32 per centum of the greater number.

In experiment B, 61·37 revolutions of the screw per minute required 330·330 net horses-power, while in experiment J, 61·25 revolutions of the screw per minute required 336·692 net horses-power, a discrepancy of $\left(\frac{336{\cdot}692 - \overline{330{\cdot}330 \div 1{\cdot}006} \times 100}{336{\cdot}692} =\right)$ 2·48 per centum of the greater number.

In experiment E, 58·78 revolutions of the screw per minute required 302·722 net horses-power, while in experiment C, 58·14 revolutions of the screw per minute required 281·041 net horses-power, a discrepancy of $\left(\frac{302{\cdot}722 - \overline{281{\cdot}041 \times 1{\cdot}0333} \times 100}{302{\cdot}722} =\right)$ 4·07 per centum of the greater number.

In experiment N, 53·68 revolutions of the screw per minute required 232·169 net horses-power, while in experiment F, 53·70 revolutions of the screw per minute required 219·063 net horses-power, a discrepancy of $\left(\frac{232{\cdot}169 - 219{\cdot}063 \times 100}{232{\cdot}169} =\right)$ 5·64 per centum of the greater quantity.

In experiment L, 51·25 revolutions of the screw per minute required 191·018 net horses-power, while in experiment G, 51·10

revolutions of the screw per minute required 189·758 net horses-power, a discrepancy of $\left(\frac{189.758 + 1.009 - 191.028 \times 100}{191.466} = \right) 0.23$ per centum of the greater quantity.

A correction of the power developed in the different experiments, may be made by ascertaining from the mean of all in the ratio of the cubes of the number of revolutions made by the screw per minute, the net horses-power required to make, say, 60 revolutions of the screw per minute, and then from it determining in the same ratio the net horses-power required for the different experimental revolutions of the screw per minute.

The following table shows the net horses-power required to give the screw 60 revolutions per minute, as computed from the tabular net horses-power developed by the engine modified in the ratio of the cube of 60 to the cube of the tabular number of revolutions made by the screw per minute. The discrepancies from the mean of all, which is 314·656 net horses-power for 60 revolutions of the screw per minute, are probably due to the too small number of indicator diagrams taken during each experiment:

Designation of Experiment.	Net horses-power required to give the screw 60 revolutions per minute.
A,	331·946
B,	308·547
C,	308·904
D,	311·339
E,	317·870
F,	305·570
G,	307·151
H,	305·325
J,	316·350
L,	306·462
M,	305·980
N,	324·168
O,	340·914
Mean of all,	314·656

From the mean of the above determinations, namely, 314·656 net horses-power for 60 revolutions of the screw per minute, the net

horses-power in the following table have been calculated for the experimental number of revolutions made per minute, by modifying the 314·656 in the ratio of the cube of 60 to the cube of the experimental number of revolutions made by the screw per minute.

The indicated horses-power in the following table have been obtained for the experimental number of revolutions of the screw per minute, on the supposition that the pressure required to work the unloaded engine and shafting was 1·5 pounds per square inch of all the pistons, and adding to the corresponding power the corrected net horses-power as above obtained.

The total horses-power in the following table have been obtained for the experimental number of revolutions of the screw per minute by adding to the corrected indicated horse-power, as above obtained, the experimental horses-power required to overcome the back pressure against the pistons.

Designation of the Experiment.	Corrected net Horses-power.	Corrected indicated Horses-power.	Corrected total Horses-power.
A,	425·289	468·636	493·162
B,	335 871	375·972	394·942
C,	286·274	324·264	349·151
D,	226·716	262·373	288·965
E,	295·871	334·508	357·621
F,	215·577	250 665	274·338
G,	194·294	227·684	248·935
H,	162 551	193 969	220 416
J,	334·888	374 910	398·247
L,	196·125	229·617	251·647
M,	309 684	348·680	372 580
N,	215·357	250 433	269·405
O,	427·014	455·883	522·318

The exact quantity of heat remains to be determined which was consumed in the production of the above horses-power. The weight of feed-water pumped into the boilers per hour may be considered nearly accurate; and, as the steam was more or less superheated when entering the valve-chest of the middle cylinder, there was doubtless no water carried over by foaming or priming. It is probable that the able experimenters assured themselves before commencing of the tightness of the pistons and steam-valves, and that there was no leakage of steam from the valve-chests or cylinders to

the condenser: the small quantity of feed-water required per hour per total horse-power in some of the experiments is evidence against such leakage. The engine being a compound one, any leakage from the middle cylinder would be intercepted by the end cylinders, and its effect correspondingly reduced; while the pressure in the end cylinders when the large measures of expansion were used, was so low that there was but little danger of leakage from them. Had there been leakage, however, of this kind, it would have affected the smaller developments of power more than the greater ones, increasing disproportionally the cost of the power with the larger measures of expansion, those measures being accompanied by smaller developments of power under the experimental conditions. The only remaining source of error was water-leakage from the boilers, in which case, other things equal, the economic vaporization of the coal should have appeared the greatest during the experiments in which the smallest powers were developed by the engine. The fact, however, was the reverse, the economic vaporization of the coal, as a rule, increasing with increasing power; and notwithstanding that, as a rule, the increasing powers were accompanied by increasing rates of combustion. There was, then, no error from this cause, and the quantity of heat in the steam entering the valve-chest of the middle cylinder can be exactly determined by multiplying the weight of feed-water consumed per hour by the number of Fahrenheit units of heat imparted to this water in each experiment, taking for that purpose the total heat in Fahrenheit units of steam of the pressure on line 7 of the large table of experimental results, (the pressure it had on entering the valve-chest of the middle cylinder) less the number of Fahrenheit units of heat in the feed-water when it entered the boiler; and adding to the quantity of heat thus obtained the number of Fahrenheit units imparted to the steam by superheating. The latter quantity is ascertained by multiplying the weight of feed-water pumped into the boiler per hour, by the number of Fahrenheit degrees of superheating (line 15 of the large table of experimental results) possessed by the steam when it entered the valve-chest of the middle cylinder, and then multiplying that product by 0·4805—the specific heat of steam compared with that of water as unity.

The quantities of heat thus obtained, expended per hour in the production of power during each experiment, are as follows:

Designation of the Experiment.	Fahrenheit units of heat consumed per hour in the vaporization of the feed-water.	Fahr. units of heat consumed per hour in the super-heating of the steam.	Fahrenheit units of heat consumed per hour in the production of the power.
A	13262966 228	63959·921	13326926·149
B	9376822·247	63687 872	9440510·119
C	8059253·354	36497 978	8095751 332
D	6936693·968	52824 343	6989518·311
E	9681923 445	90020 076	9771943 521
F	6659848·515	58282·713	6718131·228
G	5941986 380	56752·971	5998739 351
H	5127838 940	46373·207	5174212·147
J	10764053 730	98160 868	10862214·598
L	6740323·936	86282·488	6826606·424
M	9400219·647	78432·605	9478652·252
N	8012928·352	54756 794	8067685·146
O	18867096 310	00000·000	18867096 310

The quantities in the last column of the above table represent accurately the relative quantities of coal required to be consumed in the different experiments to produce the net, indicated and total horses-power in the table immediately preceding the one above. The quotients of their division into the quantities in the last column of the above table, expresses their relative cost in weight of coal consumed per hour.

The results of such divisions will be found in the following table:

Number of times the steam was expanded.	Designation of the Experiment	Cost of the net horse-power in Fahrenheit units of heat consumed per hour.	Cost of the indicated horse-power in Fahrenheit units of heat consumed per hour.	Cost of the total horse-power in Fahrenheit units of heat consumed per hour.
2·26	A	31336·165	28437 692	27023·425
3·21	B	28107·547	25109 609	23903·536
3·78	C	28279·730	24966·544	23186·963
4·59	D	30829·400	26639 625	24188·114
2·26	E	33027·717	29212·884	27324·859
3·21	F	31163·488	26801·234	24488·519
3·78	G	30874·548	26346·776	24097·613
4·59	H	31831·315	26675·459	23474·757
2·26	J	32435·365	28792 859	27275·069
2·26	L	34807·426	29730·405	27127·708
2·26	M	30607·497	27184·388	25440·583
2·26	N	37461·908	32214·944	29946·308
1·26	O	44183·789	41166·475	36121·857

The quantities in the last column of the above table show the relative cost in coal, when burned under equal economic conditions, of the total horse-power for the different experiments. Now the total horses-power measures the entire mechanical work done by the steam, both internal and external, and is the true quantity to be taken as the effect produced when the question is how the cost of steam-power in fuel is affected by the measure of expansion with which the steam is used; and independently of what fraction of this total horses-power may be utilized commercially in the cases of the different measures of expansion.

Experiments A to H, both inclusive, show that from an expansion of, say, three times to an expansion of, say, five times, the measure of expansion with which the steam is used does not affect its economy in the production of the total horses-power; and that, too, with superheated steam used in a compound engine but without steam-jacketed cylinders. Consequently, for steam of all measures of expansion between three and five times, used in the same cylinder, with the same speed of piston and with the same development of indicated horse-power by the same indicated pressure, but with unequal initial pressure, this pressure being less and less as the steam is less and less expanded, the indicated horse-power would be obtained for the same quantity of heat imparted per hour to the water in the boiler. And the same remark applies to the net horse-power, *mutatis mutandis*.

A further corollary is, that for equal developments of power with equal initial pressure in the cylinder and equal piston-speed, but with cylinders having areas in inverse proportion to the mean indicated pressure which the different measures of expansion would produce under these conditions, the indicated horse-power would be obtained for less heat expended per hour with the measure of expansion three times than with any greater measure up to five times. And the same remark applies to the net horse-power, *mutatis mutandis;* but with this modification, that the expenditure of heat with the steam expansion of three times, relatively to the heat expenditure with the greater measures of expansion, would be less to produce it than in the case of the indicated horse-power.

Experiments E, F, G, H are duplicates of experiments A, B, C, D, with the exception that they were made with a lower initial cylinder pressure, and with consequently less mean pressures upon the piston,

and less speeds of piston. As the total horse-power was obtained for the same expenditure of heat per hour in both sets of experiments for the same measure of expansion, it follows that the economy was not influenced by the speed of the piston when that speed was accompanied with the corresponding mean total pressure. Nor was the economy influenced by the mean total pressure when accompanied with the corresponding piston-speed.

The net horse-power and the indicated horse-power in experiments E, F, G, H, were obtained with the greater expenditure of heat per hour, than in experiments A, B, C, D, because the high back-pressure against the piston and the pressure required to work the engine, *per se*, being the same in both sets of experiments, while the mean total pressure was less in experiments E, F, G, H, owing to the less initial cylinder pressure, a less fraction of the total pressure was utilized as net and indicated pressures.

Experiments I (same as A), J, K (same as E), and L, were made with the same measure of expansion (2·26 times) but with continually decreasing cylinder pressures and speeds of piston. The heat expenditure per hour for the total horse-power was nearly constant, showing, as in the previous experiments, that it was not influenced by the speed of piston when accompanied by a corresponding mean total pressure, the engine working against resistances increasing and decreasing as the square of the speed of the piston increased or decreased. But the expenditure of heat per hour for the net and indicated horse-power increased with each decrease of the initial cylinder pressure, owing to the causes stated in the immediately preceding paragraph.

The fact, conclusively shown by all these experiments that, within their limits, the economy of the net and indicated horse-powers, after a very moderate measure of expansion is reached, mainly depends on the ratio of the sum of the back-pressure and the pressure required to work the unloaded engine, to the mean total pressure on the piston, is a strong reason for the use of the maximum total pressure practicable, or for the use of the highest possible boiler pressure, independently of the fact that with steam of higher pressures the product of the pressure into its volume is greater with a given expenditure of heat than with steam of lower pressures, but it must be remembered that the gain due to this cause continually decreases as the total pressure increases, because the back-pressure and pressure required

to work the unloaded engines are constant and uninfluenced by the total pressure. On the other hand, the losses by leakage, by external radiation, and by cylinder interior condensation, for equal development of power, increase with increased total pressure, so that a point is soon reached where the gains and losses balance, to go beyond which is to experience an economic loss instead of gain. This point is only determinable by experiment, like every other physical problem.

Experiments M and N were made to show the effect of using the steam much throttled. That a gain may be thus obtained is very certain in the two cases of the steam having been used with a less measure of expansion than what corresponds to the maximum economy, or having been drawn from a boiler with too little steam room. In the former case, with equal mean total pressure, as throttling the steam increases to a certain degree the measure of expansion with which it is used, an economic gain will follow: in the latter case, the effect is to increase the steam room relatively to the bulk of steam drawn out per stroke of piston, and so prevent the economic loss due to the priming or foaming over of water from the boiler to the cylinder. As the steam in these two experiments was expanded 2·26 times by the valve-gear and compounding of the cylinders, but little or no gain could be expected from any increase in that direction; and as it entered the cylinder considerably superheated, there could have been no foaming or priming to be prevented. Under these circumstances, no gain from the throttling could be expected. The mean cost of the total horse-power in Fahrenheit units of heat consumed per hour when the steam was expanded 2·26 times, was, for the four experiments in which it was used without throttling 27,188; and for the two experiments in which it was used with throttling 27,693.

Experiment O was made with only the two end cylinders working as simple engines, that is, not compounded. The steam was saturated, that is, it entered the cylinders without being superheated; and it was expanded only 1·26 times. In all respects the steam was used in this experiment under strongly opposed conditions to those under which it was used in the preceding ones. The result was that the total horse-power cost 36,122 Fahrenheit units of heat expended per hour.

In the six preceding experiments in which superheated steam was used in compounded cylinders with measures of expansion varying

from, say, three to five times, the mean cost of the total horse-power in Fahrenheit units of heat, was 23,890; there was a consequent economic gain obtained by the combined effect of using superheated heat with the most economical measures of expansion in an unjacketed compound engine of $\left(\frac{36{,}122 - 23{,}890 \times 100}{36{\cdot}122} = \right) 33\ 86$ per centum over using saturated steam in a simple engine and with scarcely any expansion.

The mean results from all the experiments, of the vaporization of water in the boilers by the coal, are as follows:

Pounds of coal consumed per hour per square foot of grate surface,	12·4889
Pounds of coal consumed per hour per square foot of heating surface,	0·4858
Pounds of water that would have been vaporized by one pound of coal, had it been supplied at the temperature of 100 degrees Fahrenheit and vaporized under the pressure of 29·92 inches of mercury,	8·3660
Pounds of water that would have been vaporized by one pound of coal, had it been supplied at the temperature of 212 degrees Fahrenheit and vaporized under the pressure of 29·92 inches of mercury,	9·3436

The coal used was the briquettes d'Anzin, with less than 4 per centum of refuse.

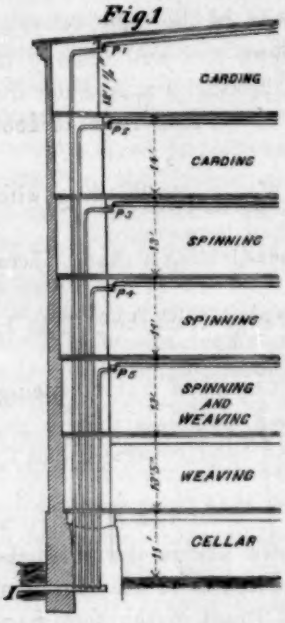
Sun Spots and Magnetism.—M. Faye has re-examined the data upon which Wolf founds his sun-spot period of 11·11 years, and also those upon which Lamont, Loomis and Braun base their magnetic period of 10·45 years. He concludes that the supposed identity of the two periods is inadmissible, and that the accordance for some years back is merely accidental. The two periods exactly corresponded about the year 1860, and the deviation during the past 18 years has been so slight that it is not strange that observers should have regarded the correspondence as a permanent one. A collection of favorable circumstances, which is reproduced every 176 years, has caused this close connection of the two phenomena. Such occasional accidental coincidences are by no means rare in the history of science. A few years ago a similar one was noticed between the sun spots and the vector-radii of Jupiter.—*Comptes Rendus.* C.

THE PROBLEM OF PERFORATED PIPES AS APPLIED TO SPRINKLERS.[1]

By J. P. FRIZELL, C. E., Boston.

A system of perforated pipes, called "sprinklers," has latterly been introduced into cotton mills for the purpose of preventing the spread of fires. The usual disposition of such pipes is indicated by Figs. 1 and 2, the former of which is a vertical section, and the latter a half plan of the Merrimack Company's Mill, No. 2, at Lowell. Each story, provided with sprinklers, has one or more vertical standpipes, communicating with the reservoir main, and controlled by valves so located as to be accessible in case of fire. Each of these standpipes communicates with a horizontal main, P_1, P_2, etc., Fig. 1, located at the side of the mill, and immediately below the beams of the overlying floor, running, generally, lengthwise of the mill. A series of smaller pipes, a_1, a_2, a_3, b_1, b_2, b_3, etc., issue from this latter at right angles, running across the mill, close under the ceiling, between the beams. Their distance apart is generally about 8 feet, being governed by the spacing of the floor-beams, windows and pillars of the mill.

Fig. 1



[1] An appendix to a report made by the writer, to Mr. James B. Francis, agent of the proprietor of locks and canals on Merrimack River. One of that gentleman's duties is the supervision of the mutual insurance organization of the manufacturers of Lowell, in which capacity he has control of the means of extinguishing fires. Contemplating a considerable extension of the system of perforated pipes, he employed the writer during the past winter to compute the quantity of water required for an entire mill, no practical method of performing such computations having been previously known. The method pointed out has been adopted by Mr. F., and is thought worth printing, for the information of the profession and others interested. The same problem occurs in other cases. The immense lock now in process of construction at Sault Ste. Marie, is to be filled through a great number of small openings from a culvert under the floor. The computation of the time required for filling this lock, involves precisely the same principles as the above problem.

They are provided with minute orifices, 6 to 12 inches apart, located alternately on opposite sides, and so disposed as to throw the water upward and outward. The diameter of the pipes, at every part of the system, is varied according to the number and size of orifices to be supplied, from 6 or 8 inches in the standpipes, to $\frac{3}{4}$ or $\frac{1}{2}$ inch in the perforated pipes near their extremities. The proper proportioning of such a system and its accessories, requires a knowledge of the quantity of water discharged. This involves a hydraulic problem of considerable intricacy, viz.: to find the relations of pressure, velocity, diameter of pipes, size and spacing of orifices at every point of this vast system. We will first consider the simplest case of a pipe of uniform diameter, with equidistant orifices of equal size:

Let the orifices be numbered 1, 2, 3, etc., n, commencing with the final orifice.

Let H_1, H_2, H_3, etc., H_n, represent the head acting at the orifices 1, 2, 3, etc., n.

Let q_1, q_2, q_3, etc., q_n, represent the discharge from the orifices 1, 2, 3, etc., n.

Let Q_1, Q_2, Q_3, etc., Q_n, represent the quantity of water passing between 1 and 2, 2 and 3, etc., $n-1$ and n.

Let h_1, h_2, h_3, etc., h_n, represent the loss of head between 1 and 2, 2 and 3, etc., $n-1$ and n.

The discharge at any orifice is expressed by a formula of the form $q = c\sqrt{H}$, in which c involves the area of the orifice, the accelerative force of gravity and another constant. The loss of head between two consecutive orifices is expressed by a formula of the form $h = bQ^2$, in which b involves the distance separating the orifices, the diameter of the pipe and another constant. We have, then:

$$q_1 = c\sqrt{H_1}.$$
$$Q_1 = q_1.$$
$$h_1 = b\,Q^2 = b\,(c\sqrt{H_1})^2 = b\,c^2\,H_1.$$
$$H_2 = H_1 + h_1 = H_1\,(1 + b\,c^2),$$
$$q_2 = c\sqrt{H_2} = c\sqrt{H_1}\sqrt{1 + b\,c^2}.$$
$$Q_2 = Q_1 + q_2 = c\sqrt{H_1}\,(1 + \sqrt{1 + b\,c^2}.)$$
$$h_2 = b\,Q_2^2 = b\,c^2\,H_1\,(1 + \sqrt{1 + b\,c^2})^2.$$
$$H_3 = H_2 + h_2 = H_1\,[1 + b\,c^2 + b\,c^2\,(1 + \sqrt{1 + b\,c^2})^2].$$

$$q_3 = c\sqrt{H_3} = c\sqrt{H_1}\sqrt{1+bc^2+bc^2(1+\sqrt{1+bc^2})^2}.$$

$$Q_3 = Q_2+q_3 = c\sqrt{H_1}\left[1+\sqrt{1+bc^2}+\sqrt{1+bc^2+bc^2(1+\sqrt{1+bc^2})^2}\right]$$

$$h_3 = bQ_3^2 = bc^2H_1\left[1+\sqrt{1+bc^2}+\sqrt{1+bc^2+bc^2(1+\sqrt{1+bc^2})^2}\right]^2$$

$$H_4 = H_3+h_3 = H_1$$

$$\left[1+bc^2+bc^2(1+\sqrt{1+bc^2})^2+bc^2\left[1+\sqrt{1+bc^2}+\sqrt{1+bc^2+bc^2(1+\sqrt{1+bc^2})^2}\right]^2\right]$$

$$q_4 = c\sqrt{H_4} = c\sqrt{H_1}$$

$$\sqrt{1+bc^2+bc^2(1+\sqrt{1+bc^2})^2+bc^2\left[1+\sqrt{1+bc^2}+\sqrt{1+bc^2+bc^2(1+\sqrt{1+bc^2})^2}\right]^2}$$

$$Q_4 = Q_3+q_4 = c\sqrt{H_1}$$

$$\left[1+\sqrt{1+bc^2}+\sqrt{1+bc^2+bc^2(1+\sqrt{1+bc^2})^2}+\right.$$

$$\left.\sqrt{1+bc^2+bc^2(1+\sqrt{1+bc^2})^2+bc^2\left[1+\sqrt{1+bc^2}+\sqrt{1+bc^2+bc^2(1+\sqrt{1+bc^2})^2}\right]^2}\right]$$

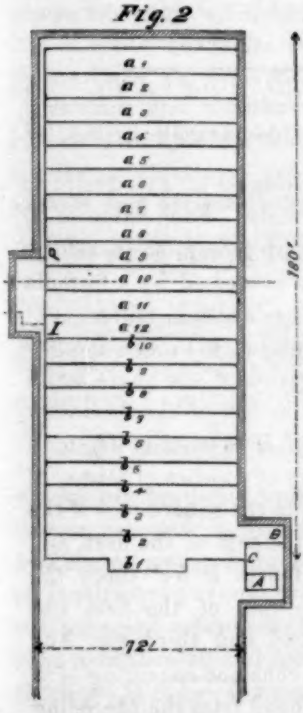
This is sufficient to show the utter hopelessness of an attempt to express the discharge in an algebraic formula. Each value of Q occupies more than double the space of the preceding, so that for a pipe of 100 orifices, the discharge would be expressed by a formula requiring not less than 25 figures to denote its length in miles.

Nevertheless, certain facts of great importance to the inquiry become apparent upon an attentive consideration of the above series of equations. It is important, first, to note the law of the formation of the formulas for H and Q. Each value of H consists of H_1, multiplied by a constant. This constant consists of a series of terms, of which the first is unity; the second is bc^2 times the square root of the first; the third is bc^2 times the square of the sum of the first, and square root of the first and second; the fourth is bc^2 times the square of the sum of the first, the square root of the first and second, and the square root of the first, second and third, etc. The value of Q consists of $c\sqrt{H_1}$ multiplied by a constant consisting of a series of terms. Any term in this series is found from the preceding terms, by placing under the radical sign the square of the immediately preceding term, plus bc^2 times the square of the sum of all the preceding terms. We can thus write the successive values of Q or H, without reference to any other element of the problem. The expression for each succeeding orifice is formed by adding to the coefficient of H_1 or $c\sqrt{H_1}$, a term consisting of a certain combination of the preceding terms. When we come to a change in the diameter

of the pipe, it is only necessary to make the proper change in the value of b in the expressions for the ensuing orifices. A similar remark applies to a change in the size or spacing of the orifices.

Since the head, acting on any orifice, consists of H_1 multiplied by a constant, it follows that the head at the origin of a pipe bears a constant proportion to that at the final orifice or any other orifice. An increase of the head at one point implies a proportional increase at all other points. The head at the origin of the perforated pipes a_1, a_2, a_3, etc., Fig. 2, increases as you approach the source of supply, I, in consequence of the loss of head in the supplying main, P. A proportional increase occurs at the final orifices.

Fig. 2



Since the total discharge of the pipe is represented by $c\sqrt{H_1}$, multiplied by a constant, the quantities discharged by similar pipes are proportional to the square roots of the heads acting on the initial orifices, or on the final orifices, or on any other orifices similarly situated. It is also apparent that in computing the discharge of the supplying main, P, the perforated pipes, a_1, a_2, a_3, etc., may be treated as orifices in the main, and the head and discharge at each represented by the above formulas, substituting proper values for b and c. It follows also that the discharge of the entire system of articulated pipes is proportional to the head at any given point in the system. It must be observed that this and the preceding paragraph apply only to pipes or systems of pipes on the same level.

Although the algebraic expression of the discharge would involve endless labor, the above formulas can be represented and extended from orifice to orifice by a geometrical construction of remarkable simplicity. Draw from A, Fig. 3 (p. 89), two lines, making an angle with each other whose tangent is $c\sqrt{b}$. Take any convenient distance, $A\,D_1$, to represent unity. Draw $D_1\,d_1$ perpendicular to $A\,C$. Make

$D_1 D_2 = A d_1$, $D_2 D_3 = D_1 d_2$, $D_3 D_4 = D_2 d_3$, etc., the several lines, $D_2 d_2$, $D_3 d_3$, etc., being perpendicular to $A C$. Then the distance, $D_1 D_2$, will represent q_2, $D_2 D_3$ will represent q_3, and $D_{n-1} D_n$ will represent q_n, leaving out of consideration the common factor $c\sqrt{H_1}$. Q_2 is also represented by $A D_2$, Q_3 by $A D_3$, Q_4 by $A D_4$, etc. Thus

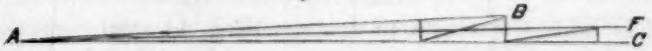
$A D_1 = 1$, $A d_1 = D_1 D_2 = \sqrt{1 + b c^2}$;

$D_1 d_2 = D_2 D_3 = \sqrt{D_1 D_2^2 + b c^2 (1 + \sqrt{1 + b c^2})^2}$, etc. Any value of Q is obtained from the preceding value, by adding the square root of the sum of two terms, of which the first is the square of the immediately preceding term, and the second is $b c^2$ times the square of the sum of all the preceding terms. For instance:

$D_7 D_8 = D_6 d_7 = \sqrt{D_6 D_7^2 + D_7 d_7^2} = \sqrt{D_6 D_7^2 + b c^2 \times A D_7^2}$. Also $\left(\frac{D_6 D_7}{C}\right)^2$ represents the head acting on the seventh orifice, and $\left(\frac{D_7 d_7}{C}\right)^2$ represents the loss of head between the sixth and seventh orifices. All on the same scale on which $A D_1$ represents the discharge from the final orifice.

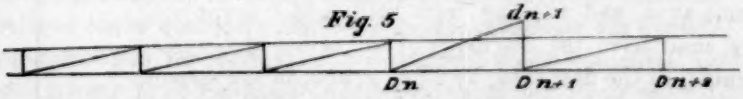
When a point is reached at which a change of diameter occurs, a new line, $A F$, Fig. 4, is drawn, corresponding to the new value of b,

Fig. 4



and the work proceeds as before, except that it is governed by the line $A F$ instead of $A B$. Usually, at a change of diameter as well as at angles, bends and couplings, a loss of head occurs in addition to that represented by $b Q^2$. Such losses are always proportional to Q^2, and may be represented by $b_1 Q^2$. At the orifice following the contraction, angle, coupling, etc., the vertical line extends above the inclined line, as in Fig. 5, being equal to $c\sqrt{b + b_1} \cdot Q_n$, and the

Fig. 5



distance $D_n d_{n+1}$ is laid off from D_{n+1} to D_{n+2}.

Having followed a perforated pipe from the final orifice to the origin, we have its total discharge and the discharge of each orifice represented by lines. We have not yet found the absolute value of

any quantity, but only their relative values. The same method is applied to the main supplying the several lines of perforated pipe. Here $A\,D_1$, $D_1\,D_2$, $D_2\,D_3$, etc., Fig. 3, represent the discharge of the successive lines of perforated pipe. We come, finally, to a point in the system where the head is known or may be assumed. Here we find the line representing the discharge of an orifice. We can also compute the same from the known or assumed head. This fixes the relation between lines and quantities of water.

Fig. 3

Fig. 2 shows a common arrangement of sprinkler pipes, the water entering the main, P, at I, and passing in both directions. Taking $\frac{1}{2}$ inch to represent the discharge of the final orifice of a_1 and working toward I, we shall find the discharge of a similar orifice at I represented by a line which we will call x. We will, for the present, leave out of consideration the irregular pipe b_1, and consider b_2 as the last pipe on that side. Taking $\frac{1}{2}$ inch to represent the discharge of the final orifice of b_2, and working toward I, we shall find the discharge of the above mentioned orifice represented by a line different from x, which we will call x_1. We shall also have a line representing the total quantity going from I toward b_1. We must multiply this latter by $\frac{x}{x_1}$, before adding it to the line representing the total quantity going from I toward a_1. The sum represents the total discharge of the system by a line of which each half inch represents the discharge of the final orifice of a_1.

Perforated pipes sometimes terminate as at A, B, C, Fig. 2. The method here is similar to that given above. Taking $\frac{1}{2}$ inch to represent the discharge at B, and the same at A, and working from both points towards C, we shall have the discharge of an orifice at C represented, in the first case, by a line x, and, in the second, by a longer line x_1. This simply indicates that if half an inch represent the discharge of an orifice at B, that of an orifice at A should have been represented by a shorter line a. The length a should be such as to make the discharge

of an orifice at C the same as is found by taking $\frac{1}{2}$ inch for the discharge of an orifice at B, whence $a : \frac{1}{2}$ inch $= x : x_1$, or $a = \frac{x}{x_1}$ times $\frac{1}{2}$ inch. The line denoting the discharge of each orifice between A and C, must be reduced in the same proportion; hence, we multiply the sum of these lines by $\frac{x}{x_1}$. We now proceed to determine the discharge of b_1, on a scale in which $\frac{1}{2}$ inch represents the discharge of an orifice at B. Arriving at the origin of b_2, by the way of b_1 and b_2, we are in a position to reduce our result to a scale in which $\frac{1}{2}$ inch represents the discharge of the final orifice of b_2. We use this scale till we reach I, when the final reduction is made, as above.[1]

The preceding refers to horizontal pipes. A special construction is required for a pipe laid at an inclination, as is necessary in the upper rooms, immediately below the roof. In this case we can only determine the discharge for some known or assumed value of the head acting on the final orifice. The loss or gain of head between

Fig. 6

two consecutive orifices, consequent on the slope of the pipe, is a known quantity, and the line which represents it must have the proper relation to that which represents the discharge from the final orifice. Such pipes, however, only occur at the top of the mill, which is precisely the point where the head is known or may be assumed.

Let h_s be the difference of level between two consecutive orifices.

Let h_v be the loss of head due to velocity between two consecutive orifices.

Draw the lines $A\,B$, $C\,F$, Fig. 6, as in the case of level pipes, and draw $G\,K$ parallel to $C\,F$, at a distance therefrom $= c\sqrt{h_s}$. Then, for the case in which h_s is negative, *i. e.*, in which the water descends in moving through the pipe, let $D_1\,D_2$, Fig. 6, represent the discharge

[1] The method of reduction described is simply an application of the principle that the discharge is proportional to the square root of the head.

from any orifice. Draw the verticals, $D_1 d_1$, $D_2 d_2$; take $D_1 D_2$ as a radius, and d_2 as a centre, and touch $C F$ at e_1, $e_1 f_2$ will be the discharge of the next orifice; lay this off from D_2 to D_3, and proceed as before. For, let H_2 = the head acting on the orifice at D_2, then

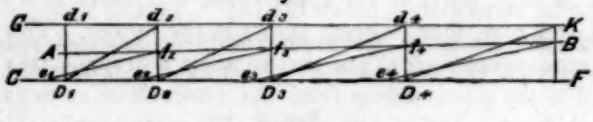
$$q_2 = c\sqrt{H_2} = D_1 D_2 \cdot D_2 f_2 = c\sqrt{h_v}, \text{ and } D_2 d_2 = c\sqrt{h_s},$$

$$e_1 f_2 = \sqrt{e_1 D_2^2 + D_2 f_2^2} = \sqrt{e_1 d_2^2 - d_2 D_2^2 + D_2 f_1^2} = \sqrt{c^2 H_2 - c^2 h_s + c^2 h_v}$$

$$= c\sqrt{H_2 - h_s + h_v} = c\sqrt{H_3}.$$

For the case in which h_s is positive, viz., when the water ascends in moving through the pipe, let $D_1 D_2$, Fig. 7, represent q_2, the discharge from the orifice D_2. Draw the verticals $D_1 d_1$, $D_2 d_2$. With D_2 as centre, and $D_2 d_1 = D_1 d_2$ as radius, fix the point e_1 on the line $C F$, $e_1 f_2$ is the discharge of the ensuing orifice. Lay this off from

Fig. 7



D_2 to D_3. Draw the vertical $D_3 d_3$, and proceed as before. For

$$e_1 f_2 = \sqrt{e_1 D_2^2 + D_2 f_2^2} = \sqrt{D_1 D_2^2 + D_2 d_2^2 + D_2 f_2^2} + c\sqrt{H_2 + h_s + h_v} = c\sqrt{H_3}$$

If we deduce the general algebraic expressions for H and Q, as in the case of level pipes, they will have the form:

$$H n = H_1\left[1 + bc^2 \pm (n-1)\frac{h_s}{H_1} + bc^2\left(1 + \sqrt{1 + bc^2 \pm \frac{h_s}{H_1}}\right)^2 + \text{, etc.}\right].$$

$$Q_n = c\sqrt{H_1}$$

$$\left\{1 + \sqrt{1 + bc^2 \pm \frac{h_s}{H_1}} + \sqrt{1 + bc^2 \pm 2\frac{h_s}{H_1} + bc^2\left(1 + \sqrt{1 + bc^2 \pm \frac{h_s}{H_1}}\right)^2} + \text{etc.}\right.$$

$$\left. + \sqrt{1 + bc^2 \pm (n-1)\frac{h_s}{H_1}} + \text{ etc.}\right.$$

These forms disclose a difficulty in inclined pipes not met with in level pipes, to wit:—Since the coefficient of H_1, in the expression for H, is not constant, a change of head at any orifice does not imply a proportional change at any other orifice, and, for the same reason, the

total discharge is not proportional to the square root of the head at any orifice. An approximate method of determining the increase of discharge consequent upon an increase of head, in a series of similar pipes, is, to compare the orifice giving the average discharge, in the pipe remotest from the source of supply, for which the graphical computations have been made, with corresponding orifices in other pipes.

The object of the sprinklers being to arrest a fire at its commencement, the necessity for putting them in operation throughout the entire mill at the same time, would hardly ever arise. Nevertheless, as the apparatus is necessarily confided to the care of a watchman on whose discretion little reliance can be placed, the simultaneous operation of the entire system must be contemplated. The difficulty which arises here, when the size and distribution of the orifices are uniform throughout the mill is this:—Some parts of the lowest room are liable to receive three or four times as much water per square foot of area as some parts of the upper room.[1] If there is a sufficiency in the latter case, there is great excess in the former. This would be of no consequence were it not that so great a draught may diminish the head in the pipe leading from the reservoir so as to exclude the water wholly from the upper room. Were it possible to furnish a uniform supply to all parts of the mill, it would be easier to avoid this difficulty. It seems essential to the completeness of this paper to indicate a method of spacing the orifices and arranging the pipes so as to secure this end. This will only be attempted upon the supposition of level pipes though undoubtedly possible for inclined pipes.

Commencing with the final orifice, let the distance from orifice to orifice be denoted by l_1, l_2, l_3, l_4, etc. The value of b will be different for each orifice, viz., $b_1 = b$, $b_2 = b_1 \frac{l_2}{l_1}$, $b_3 = b_1 \frac{l_3}{l_1}$, etc. Then the con-

[1] The inequality is often much greater than this. In a mill provided with sprinklers, at Lowell, to which this method was applied, it was found that some parts of the same room would receive fourteen times as much water per square foot of floor as others, the heads differing nearly in the ratio of 1 to 200. It is easy to conceive that such an arrangement might defeat its own purpose, furnishing no effective supply of water to the point where the fire exists. It must be borne in mind that it is only by calculation that the working of a system of sprinkler pipes can be ascertained, an experimental test being out of the question.

dition that the discharge of an orifice, divided by its distance from the succeeding orifice, shall be constant, gives

$\frac{q_1}{l_1}=\frac{q_2}{l_2}=\frac{q_3}{l_3}$, etc., whence $\frac{l_2}{l_1}=\frac{q_2}{q_1}=\sqrt{1+b\,c^2}$, and $l_2=l_1\sqrt{1+b\,c^2}$;

also

$$q_3=\frac{l_3}{l_1}q_1=\sqrt{q_2^2+b_2c^2(q_1+q_2)^2}=\sqrt{\left(\frac{l_2}{l_1}\right)^2 q_1^2+b\frac{l_2}{l_1}c^2\left(q_1+q_1\frac{l_2}{l_1}\right)^2};$$

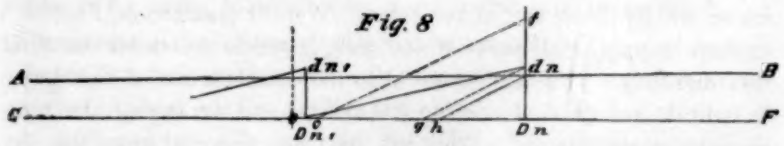
whence $\frac{l_3}{l_1}=\sqrt{\left(\frac{l_2}{l_1}\right)^2+b\,c^2\frac{l_2}{l_1}\left(1+\frac{l_2}{l_1}\right)^2}$ and $l_3=\sqrt{l_2^2+b\,c^2\frac{l_2}{l_1}(l_1+l_2)^2}$.

In like manner we find $l_4=\sqrt{l_3^2+b\,c^2\frac{l_3}{l_1}(l_1+l_2+l_3)^2}$, and

$$l_n=\sqrt{l^2_{n-1}+b\,c^2\frac{l_{n-1}}{l_1}(l_1+l_2+l_3+\text{etc.},+l_{n-1})^2}.$$

The successive values of l may be found by geometrical construction, in the following manner: The lines $A\,B$, $C\,F$, Fig. 8, being

Fig. 8



supposed to make an angle with each other whose tangent is $c\sqrt{b}$, let $D_{n-1}\,D_n$ be any two consecutive orifices, l_{n-1} being the distance between them. Lay off $D_{n-1}\,e$, $D_{n-1}\,c$, each equal to $\frac{1}{4b_1}$. With e D_n as radius, and c as centre, touch the prolongation of $D_n\,d_n$ at f. From D_n lay off, $D_n g=D_n f$ and $D_n h=$ unity. Draw $g\,k$ parallel to $h\,d_n$. Then will $D_{n-1}\,K=l_n$. For imagine a parabola defined by the equation $y^2=\frac{l}{l_1}=2\,\frac{1}{2l_1}\,l$. D_{n-1} being the vertex of the curve, and $C\,F$ its axis, c is the focus, and e is on the directrix, since both these points are at a distance from the vertex equal to half the parameter. f is a point in the curve, being equidistant from the focus and directrix, and $f\,D_n=\sqrt{\frac{l_{n-1}}{l_1}}\,D_n\,k=D_n\,d_n\sqrt{\frac{l_{n-1}}{l_1}}=c\sqrt{b}$ times the sum

of all the preceding values of l multiplied by $\sqrt{\frac{l_{n-1}}{l_1}}$, and

$$D_{n-1}\, k = \sqrt{r^2_{n-1} + b\, c^2 \frac{l_{n-1}}{l_1}(l_1 + l_2 + l_3 +, \text{etc.}, + l_{n-1})^2} = l_n.$$

As the head is different for every different pipe, l_1 should be proportional to the head acting on the pipe at the origin, final orifice, or any other point chosen for comparison. If the spacing is made the same in every room, the desired result may be secured by adopting a different size of orifice for each room, the area of the orifice being inversely proportional to the square root of the head acting upon the room system at the point chosen for comparison.

If both the size and distribution of the orifices are identical for every room, uniformity in the supply may be attained by diminishing the size of the pipes supplying the lower rooms or by introducing angles or contractions therein so as to occasion a loss of head for each story in excess of that for the story above, equivalent to the difference of height.

It must be remembered that the figures illustrating the geometrical construction are drawn on a very distorted scale. The angle defined by $c \sqrt{b}$, as tangent, is exceedingly small, and, in constructing the values of q, commencing with the final orifice, they will usually have to be laid off equal for several orifices, till the interval between the lines is appreciable. Likewise the value of l, starting from the final orifice, will be equal till there is a sensible interval between the lines, and for a number of orifices beyond, they will be found in the same way as that of q, till the interval between the lines is sufficient to give a sensible effect to the subsidiary construction.

For such exceedingly delicate measurements, sheet lead has been found better than paper to draw upon.

Vibrations of Matter and Æther.—M. Faye regards the emission and the absorption of radiant heat by a gas, as correlative proportions. In emission, molecular vibrations generate æthereal waves; in absorption, the æthereal waves increase the amplitude of the synchronous molecular vibrations; in each case there is an exchange of living forms between the matter and æther.—*Comptes Rendus.* C.

A NEW METHOD OF REDUCTION FOR DIFFRACTION SPECTRA OBSERVATIONS.

By Emil Rosenberg, M. D., New York.

The apparatus employed is one of those ordinary two-tube spectroscopes, provided with a simple photograph scale placed in the eyepiece of the observing telescope, and presenting divisions from 0 to 160 (actually from 10 to 160.) Though allowing only approximate determinations, such a scale is found, in certain respects, to answer our purpose better than other descriptions of measuring apparatus.

The necessity of communicating spectrum observations by referring them to wavelengths, instead of to an arbitrary scale, has long been established. The arbitrary, individual scale of a prismatic spectrum is easily converted into the rational scale of the Normal Spectrum by various methods. Though these do not here concern us, we may call the attention of observers to a table, computed by Professor Vierordt ("Die quantitative Spectralanalyse, Tübingen," 1876, page 104), which we have found very useful for this purpose.

The diffraction-grating gives the desired wavelengths directly by the well known proceeding, which ought certainly not to be replaced by a less exact method. Setting aside, however, the circumstance that not every spectroscopist is provided with the necessary measuring apparatus, there are other obvious reasons for the employment of convenient reduction-methods. Spectroscopical work is not confined to occasional investigations of the discoverer, who will prefer direct measurement, but the accumulated facts and results find eager students intent upon their acquisition. The study of established facts requires occasionally other methods than the original investigator was obliged to employ. Even the latter will, in time-consuming examinations, avail himself of reduction methods, if they permit exact determination. Moreover, the author believes that certain features of the method offered in this paper will even be profitably employed in combination with direct measurement.

The essential point for a convenient reduction-method is, to use a position of the grating, which should yield a simple and—for all regions of the spectrum—*equal* ratio of distances of the Fraunhofer lines in reference to a standard scale.

As such we adopt Angström's tenth-metre scale.

Searching for such a simple ratio with Mr. L. M. Rutherfurd's transparent 6481-line grating (which may be called R_a), the author found for the position of minimum deviation,

All distances of Spectrum I at the ratio 1:20 of Angström's,
" " " II " 2:20 "
" " " III " 3:20 " etc.

Starting from this *observation*, the following relations were established for a series of diffraction-gratings:

TABLE I.

Designation of Grating.		Number of intervals per English inch.	Multiples of 540	Multiples of 2160	Relation of Distances (at min. dev. position) to tenth-metre scale, for Spectrum. I.	II.	III.	IV.	V.	VI.
Nobert's Gratings, employed by Angström.	A_{iii}	2160	4	1	$\frac{1}{60}$	$\frac{1}{30}$	$\frac{1}{20}$	$\frac{1}{15}$	$\frac{1}{12}$	$\frac{1}{10}$
	A_{v}	2700	5	$1\frac{1}{4}$	$\frac{1}{48}$	$\frac{1}{24}$	$\frac{1}{16}$	$\frac{1}{12}$	$\frac{5}{48}$	$\frac{1}{8}$
	A_{ii}	3240	6	$1\frac{1}{2}$	$\frac{1}{40}$	$\frac{1}{20}$	$\frac{3}{40}$	$\frac{1}{10}$	$\frac{1}{8}$	$\frac{3}{20}$
	A_{iv}	4320	8	2	$\frac{1}{30}$	$\frac{1}{15}$	$\frac{1}{10}$	$\frac{2}{15}$	$\frac{1}{6}$	$\frac{1}{5}$
	A_{i}	5400	10	$2\frac{1}{2}$	$\frac{1}{24}$	$\frac{1}{12}$	$\frac{1}{8}$	$\frac{1}{6}$	$\frac{5}{24}$	$\frac{1}{4}$
Rutherfurd's Gratings.	R_a	6480	12	3	$\frac{1}{20}$	$\frac{1}{10}$	$\frac{3}{20}$	$\frac{1}{5}$	$\frac{1}{4}$	$\frac{3}{10}$
	R_b	8640	16	4	$\frac{1}{15}$	$\frac{2}{15}$	$\frac{1}{5}$	$\frac{4}{15}$	$\frac{1}{3}$	$\frac{2}{5}$
	R_c	17280	32	8	$\frac{2}{15}$	$\frac{4}{15}$	$\frac{2}{5}$	$\frac{8}{15}$	$\frac{2}{3}$	$\frac{4}{5}$

A grating of 129,600 intervals per inch would, theoretically, answer the tenth-metre scale, though actually no spectrum could be obtained from such a plate. This number may, however, be employed for finding the relation of any grating to Angström's scale. Thus, f. i., 8100 intervals per inch would present the ratio $\frac{1}{16}$ for Sp. I; a grating with a ratio of $\frac{1}{10}$ A for Sp. I, must have 12,960 intervals per inch.

The coefficients, given in Table I, have been verified for Sp. I and II of the following gratings:

A_{v} (a photograph),
A_{iv} (ruled on glass, by Mr. Rutherfurd),
R_a (a photograph),
R_b, R_c (ruled on speculum metal).

These coefficients will serve various purposes:

1. For finding the correct position of minimum deviation of any grating belonging to the series, through the distances of the Fraunhofer lines, for Sp. I.

2. For determining rational scale-numbers directly from known wavelengths.

3. For determining wavelengths from observed scale-numbers.

4. For finding the number of intervals or lines of a grating, etc.

The reduction-method, based upon this definite relation, will recommend itself by its simplicity.

The grating being placed, in the usual way, at the presumptive position of minimum deviation, the latter is approximately corrected (by means of the photograph scale) by equalizing the ratio of distances of the Fraunhofer or metal lines, in reference to A's distance, according to the coefficient for Sp. I.

Thus, R_a would be adjusted to such a position, that, f. i.,

A's distance C	— D″ = 667	tenth metre	would be reduced to	33 div.,	3,
D″	— E = 626	"	"	31 div.,	3,
E	— b' = 86	"	"	4 div.,	3,
Li α	— Na = 813	"	"	40 div.,	6,
Na	— Th = 543	"	"	27 div.,	1, etc.

A *continuous*, rational scale is then formed, the *scale-numbers* being obtained directly from the known wavelengths, by multiplying λ by the respective coefficient, in this instance, by $\frac{1}{20}$.

The *wavelength* is found from the observed scale-number, by multiplying the latter by the *inverted* coefficient, in this instance, by 20.

For R_a I, the scale-numbers are found by multiplying λ by $\frac{2}{15}$; the wavelength, by multiplying the observed scale-number by $\frac{15}{2}$.

It is scarcely necessary to remark, that for determination of *unknown* wavelengths, a more delicate measuring apparatus (micrometer screw or similar means[1]) will have to replace the photograph scale, after this has done its work.

Simple, as this method is, it was reached only after and through another more complicated one, which must be mentioned, though not recommended for practical application.

This latter method gives a *discontinuous* scale, each spectrum being observed in five separate strips, each being destined for a

[1] Prof. Rood's micrometer eye-piece, (*Silliman's Journal*, 1873.)

certain number of rays (999 tenth-metre actually fitting the scale from 0 to 160).

The first strip for rays of 3000 to 3999 tenth metre,
" second " " 4000 to 4999 "
" third " " 5000 to 5999 "
" fourth " " 6000 to 6999 "
" fifth " " 7000 to 7604 "

These strips are numbered respectively 3, 4, 5, 6 and 7. An incidental feature of this method is the separation of λ in two parts, viz.:

1. The first figure.

2. The balance, which is designated "*l*." Thus, of λ 6705, 4, we call "*l*" the number 705, 4. The rational scale-number is here found from the known wavelength by multiplying *l* by the proper coefficient, and placing the number found in the strip indicated by the first figure of the wavelength.

Spectrum *I* of R_a, arranged in 5 parts would accordingly read as follows:

Strip-number.							
7						*a* 9·18	*A* 30·2
				α	*C*	*Liα*	*B*
6				13·835	28·105	35·27	43·355
			b_1	*E*	*Th*	*D*	
5			9·155	13·456	17·458	44·656	
		h	*G*	*Srδ*	*F*		
4		5·06	15·362	30·38	43·037		
R	*Q*	*P*	*O*	*N*	*M*	*L*	H_1	*H*
3	8·8	14·3	18	22	29	36·45	40·95	46·65	48·405

The wavelength is here found, by multiplying the observed scale-number by the *inverted* coefficient. The product is "*l*," to which the strip-number has to be prefixed as 1st figure.

A scale-number would, by this method, be incomplete without adding the strip-number in brackets; *e. g.*, 35, 27 (R_a *I*, 6) = scale-number for *Liα*.

We now return to the simple method:

By an observation made upon the two gratings, A_{iv} and A_v, the length of the first dark space, for any grating of the series, was directly determined. With these two gratings, the dispersion—in the minimum deviation position—is very small, showing the Normal simultaneously with H_1 and several other Fraunhofer lines.

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The scale-numbers for H_1—as calculated from λH_1—were found by observation to correspond with the distance from the Normal in actual divisions of the scale.

The same holds good for Angström's wavelengths, which represent distances from an ideal Normal in divisions of *his* scale, in tenth-metres.

Direct observation showed the length of the first dark space for A_{iv}, to be about 100 div., for A_v about 63 div.

The scale-number: H_1 for A_{iv} was observed at about 131, for A_v at about 82 (calculated respectively 131, 1 and 81, 9.)

From comparing the distance H_1—Normal (A_{iv} I) with the corresponding scale-number H_1 in the five strip arrangement: 31, 1—the first dark space was concluded to measure here exactly 100 div., the interval between 100 and 131, 1 being evidently filled by the ultraviolet spectrum.

In the same way the first dark space for A_v I was determined as measuring 62·5 div.

By means of the "reference numbers," the corresponding relations for the entire series[1] were then easily found, as detailed in Table II.

TABLE II.

Grating.	Intervals per inch.	Reference-Number (Compare Table I).	Length of first dark space, the normal being placed at 0 div.	Scale number for H_1 (I). (Continuous scale.)
A_{iii}	2160	4 or 1	50 div.	65·55 div.
A_v	2700	5 or $1\frac{1}{4}$	62·5 "	81·93 "
A_{ii}	3240	6 or $1\frac{1}{2}$	75 "	98·32 "
A_{iv}	4320	8 or 2	100 "	131·1 "
A_i	5400	10 or $2\frac{1}{2}$	125 "	163·87 "
R_a	6480	12 or 3	150 "	196·65 "
R_b	8640	16 or 4	200 "	262·2 "
R_c	17280	32 or 8	400 "	524·4 "

The dark space of Angström's spectrum would measure 3000 div. of his scale, 933 div. belonging to his ultraviolet.

There is another result of this reduction-method, which the author wishes to submit to the indulgent reader.

[1] Only those gratings of the "series," which actually exist, are specified in this paper.

By comparing our scale-number for

D (M), R_a I

294 div., 60625,

with its directly measured angle of deviation from the Normal,

$8° 39' = 519'$,

one division of our scale was found to be equivalent to 1′, 762.

This holds good for any grating of the series, and for any order of spectrum.

We were thus enabled to compute in the easiest manner the "angles" for all the principal Fraunhofer lines for a number of gratings.

By employing the above-mentioned number, the angle for the D line (R_a I) was computed as 8° 39′ 5″, 7.

The measured angle 8° 39′ being certainly correct, as far as the division of the circle allowed, we might be satisfied with this base for our computations.

We believe, however, to have found a reason for changing the equivalent 1′, 762 for 1′, 8, which would make the specified angle

8° 50′ 17″, 4.

We may be permitted to state the considerations upon which our reasoning is based.

The angles corresponding to Angström's wavelengths may be calculated in the same way, as indicated above for the spectra of actually existing gratings. We find it, in fact, convenient to calculate these phantom angles from the wavelengths, and to reduce them according to the coefficients for the various gratings.

Employing for this purpose the number 1, 762, we find the angle corresponding to wavelength

1000 =	29° 22′,	while by employing	1, 8 =	30°,
2000 =	58° 44′,	"	"	" = 60°,
3000 =	88° 06′,	"	"	" = 90°,
4000 =	117° 28′,	"	"	" = 120°,
5000 =	146° 50′,	"	"	" = 150°,
6000 =	176° 12′,	"	"	" = 180°,
7000 =	205° 34′,	"	"	" = 210°.

It is this striking regularity and harmony which leads us, at least, to doubt the correctness of the usual measurements. Instrumental means for investigating and deciding this matter are not at our disposal.

MEMOIRS ON THE LIQUEFACTION OF OXYGEN, THE LIQUEFACTION AND SOLIDIFICATION OF HYDROGEN, AND ON THE THEORIES OF THE CHANGES IN CONDITION OF BODIES.

By R. PICTET.

Translated for the JOURNAL OF THE FRANKLIN INSTITUTE, by P. PISTOR, M. E.

[Continued from Vol. lxxvi, page 26.]

III.—RECORD OF THE EXPERIMENTS.

Before making any definite experiments, as complex as those about to follow, each apparatus should be separately examined and its action corrected; thus we pass from the simple to the intricate. These preliminaries belong entirely to the domain of practice; equations, theories, have no bearing on them.

It is necessary to have the joints absolutely tight; the valves to close hermetically; as little friction as possible; good packing; very exact, corrected manometers; accurate thermometers; absolutely pure chemicals. There are a thousand details, too many to enumerate, each of which, however, is so important that the least oversight or inadvertency will entirely compromise final success. The slightest admission of air, so easily occurring, with four ordinary pumps working at a barometric vacuum, would be an inevitable cause of stoppage, and must be prevented at all hazards.

In generating the carbonic acid by the action of chlorhydric acid on marble, the gas must be dried, the primary substances examined, and the gasometer completely freed of air. For the oxygen, the chlorate of potassa must be absolutely pure and dry, and must be introduced, so that no foreign body can get mixed with it.

Finally, a thousand precautions must be taken, and it may be affirmed that none too many can be adopted. In this respect we owe a gratefully acknowledgment to M. le Dr. Monnier, Professor of Biological Chemistry at the University of Geneva, who has lent us his aid with great kindness, as well as to M. Walter, his assistant, and to M. Burgin, engineer, a member of our society.

The first (incomplete) experiments consisted in obtaining the low temperatures regularly, and maintaining them for several hours, so as to feel sure of this essential part of the preparations. It cost us more than fifteen days of trials and experiments to reach a satisfactory result. This is briefly what those experiments taught us.

The first condenser I made for the carbonic acid, consisted of a copper worm immersed in a recipient of the same metal, containing liquid sulphurous acid. When the temperature of the sulphurous acid went below — 65°, the carbonic acid would then solidify in the interior of the worm; the pressure would, in a few instants, reach 12 or even 14 atmospheres, as the worm being entirely full, the condensing surface would almost completely disappear.

This accident induced me to adopt the arrangement shown in Plate I.[1] The worm was replaced by a tube six centimetres, in diameter. Then solidification need not be feared if it should occur, as the available volume is more than sufficient to accommodate the whole contents of the gasometer.

During this first series of preliminary experiments, I recorded the maximum tensions of the vapors, of carbonic acid and of protoxyde of nitrogen, corresponding to the temperatures indicated by an alcoholic thermometer, constructed by the firm of Salleron, of Paris. These observations give figures which are materially different from those found in the books on physics, especially those relating to protoxyde of nitrogen. Further on I will give these figures in a table.

Once accustomed to the co-ordinated motions required to set the four pumps in operation and to regulate the cocks, I proceeded, on the morning of the 22d of December, 1877, to make a complete experiment. The following is an abstract of my notes taken during the experiment:

1st experiment of December 22.—The pumps are started at nine o'clock in the morning. The temperature rapidly falls in tube R.

9.30.—The temperature is — 55°. The carbonic acid pumps are started. The gasometer descends. The pressure of the carbonic acid is 6 atmospheres. It slowly rises during the working of the pumps to 8 atmospheres.

9.50.—The temperature is — 49°; the pressure 8·5 atmospheres. I stop the admission of carbonic acid to the pumps.

10.20.—Temperature — 65°; pressure 8·9 atmospheres.

[1] See preceding number of the JOURNAL.

I allow a slight admission of gas.

10.40.—Temperature —60; pressure 5 atmospheres.

800 litres of carbonic acid gas are already liquefied.

Hoar frost covers the lower part of the oxygen manometer *m'*.

10.50.—The flask is screwed on to tube A. It is charged with 700 grammes of chlorate of potassa, mixed with 250 grammes of chloride of potassium, bruised together in a mortar, sifted and thoroughly dried.

11.—The crown of gas under the flask is lighted.

Carbonic acid is admitted more freely into the pumps. The pressure rises to 10 atmospheres; the temperature —48°. We are sure that all the carbonic acid has passed over into the long tube *D*, as hoar frost appears on pipe *c''* which connects with the upper part of tube *D*.

11.15.—Pipe *c''* is connected with the suction of the pumps; the temperature of the carbonic acid reaches a minimum, —130°.

11.35.—The oxygen manometer *m'* records an increasing pressure of about 5 atmospheres.

The influence of the two circulations of sulphurous and carbonic acids is completely established.

12.10.—The oxygen manometer records 50 atmospheres.

12.16.—The pressure rises to 60 atmospheres, then rises gradually as follows:

12.23.	Pressure	70	atmospheres.
12.29.	"	80	"
12.34.	"	90	"
12.36.	"	100	"
12.37.	"	150	"
12.37.25.	"	200	"
12.38.	"	460	"
12.39.	"	510	"
12.39.30.	"	522	"
12.40.	"	525	"
12.42.	"	526	"
12.44.	"	525	"
12.48.	"	505	"
12.50.	"	495	"
1.00.	"	471	"
1.05.	"	471	"

The pressure is stationary, consequently all the chemical and physical phenomena have terminated.

The condensation has caused the fall of pressure recorded by the manometer, and the whole volume represented by the interior capacity of tube A, is full of liquid oxygen. There is certainly an excess of gas, which causes a higher pressure than the maximum tension due to the temperature of liquid carbonic acid.

1.10.—The pressure is exactly at 470 atmospheres; I open the screw plug which closes tube A.

A liquid jet issues with great violence, and assumes the appearance of a brilliant white pencil. A bluish halo surrounds this jet, especially its lower part. The length of the liquid pencil is about 10 or 12 centimetres and about 1·5 to 2 centimetres in diameter. The jet lasts about three or four seconds.

I close the regulating cock; the pressure is still 396 atmospheres. In a few minutes it falls to 352, where it remains stationary for about three minutes.

1.18.—I reopen the screw plug, a second liquid jet issues similar to the first one. But following it, the gas escapes of well-defined aeriform appearance. The gas in expanding creates a mist by its partial condensation; however, it is evident that it issues from the orifice in a different form from that which it previously had, there being certainly no liquid in the tube.

1.19.—The pressure is 50 atmospheres. The gas escapes, still producing a visible bluish mist, but with no evidence of liquid being carried with it.

Hot coals, placed under the second jet, blaze up in an instant with great violence, throwing sparks in all directions.

This first experiment is amply sufficient to demonstrate experi mentally that oxygen can be liquefied.

The variation of the pressures is a still more positive proof, if that were possible, than the appearance of the jet at the opening. However, the perfect harmony which exists between these closely related phenomena, and the possibility of introducing all these numerical data into the calculations, induced us to repeat the same experiment several times in succession, so as to be able to determine the density of liquid oxygen as well as its maximum tension for a given temperature. These two physical elements are the most important, and characterize the general properties of the new fluid. With this object we describe five consecutive experiments which enable us to obtain accurate numerical mean values.

We measured with the greatest care the following—

1. The total weight of chlorate of potassa and of the chloride of potassium introduced into the flask.

2. The temperature at which the reaction occurred.

3. The exact volume of the chloride of potassium constituting the residue.

4. The volume occupied by the compressed oxygen.

5. The contents of the tube in which the oxygen is to be condensed.

6. The theoretical pressure which should be reached in case there were no condensation.

7. The pressure reached at the moment the chlorate of potassa is decomposed.

8. The static pressure after condensation.

9. The variation of the manometer after the first jet, when a second condensation commences.

10. The static pressure after condensation, when the tube is entirely filled for the second time. This pressure is characterized by the hand remaining stationary during several minutes.

11. The same after the second jet.

12. To determine, by the position of the hand, of the manometer, the maximum pressure at which condensation occurs.

This position is found when the hand recedes less than would be due to the condensation of a volume of liquid equal to the volume of the chilled tube. The permanency of this pressure is a sure and infallible sign which enables us to determine this maximum tension readily.

13. The temperature of the solid carbonic acid enveloping tube A.

14. The density of the gaseous oxygen.

These different numerical data enable us to compute the "density of liquid oxygen" with sufficient exactitude, as we will prove later. As it is useless to encumber this pamphlet with figures, we will relate but one of the five experiments made, December 27th, at 8.10 P. M. The others, conducted in a similar manner, only differ in the recorded duration of the jets and in a few differences in pressure, which we will specify in the tables.

Experiments of December 27th, at 8.10 P. M.—The ice-pumps are started at about eight o'clock, and the carbonic acid pumps soon after.

At 9.30 the hoar frost appears on the return tube c″, showing that the large tube *D* is completely filled with solid carbonic acid. Our metallic manometer, showing an error of 29 atmospheres at the start, we give below the pressures corrected for this error of the dial. An error of no importance, however, as regards the absolute value of the observations.

8.32	P. M.	. .	Pressure	50	atmospheres.
8.38.20	"	. .	"	60	"
8.45	"	. .	"	70	"
8.50.10	"	. .	"	80	"
8.51.40	"	. .	"	90	"
8.52	"	. .	"	100	"
8.52.15	"	. .	"	155	"
8.52.30	"	. .	"	220	"
8.52.45	"	. .	"	310	"
8.52.55	"	. .	"	390	"
8.53	"	. .	"	490	"
8.53.15	"	. .	"	520	"
8.53.30	"	. .	"	525	"
8.53.45	"	. .	"	526	"
8.54	"	. .	"	525	"
8.55	"	. .	"	523	"
8.57	"	. .	"	500	"
8.59	"	. .	"	489	"
9.00	"	. .	"	480	"
9.5	"	. .	"	475	"
9.10	"	. .	"	472	"
9.15	"	. .	"	471	"
9.17	"	. .	"	471	"

The pressure having become stationary, I open the plug-cock ; a jet of liquid escapes, illuminated by a halo of electric light. The previously described appearance can be clearly observed. At the moment of closing, the pressure is exactly 432 atmospheres.

9.17.15	P. M.	. .	Pressure	432	atmospheres.
9.18	"	. .	"	429	"
9·19	"	. .	"	422	"
9.20	"	. .	"	412	"
9.21	"	. .	"	405	"
9.22	"	. .	"	395	"
9.23	"	. .	"	390	"
9.24	"	. .	"	386	"
9.25	"	. .	"	383	"

9.26	P. M.	. .	Pressure	380	atmospheres.
9.27	"	. .	"	379	"
9.28	"	. .	"	378	"
9.29	"	. .	"	378	"
9.30	"	. .	"	378	"
9.31	"	. .	"	378	"
9.32	"	. .	"	378	"
9.35	"	. .	"	378	"

The pressure has become stationary a second time, the manometer has recorded steadily falling pressures, from 432 to 378 atmospheres, where it again remains stationary. Difference 54 atmospheres.

I open the plug-cock; a jet escapes similar to the first, and of the same duration. As soon as traces of gas manifest themselves at the orifice, I conclude that all the liquid has escaped, and close the cock instantly.

9.35.15	P. M.	. .	Pressure	291	atmospheres.
9.36	"	. .	"	285	"
9.37	"	. .	"	280	"
9.38	"	. .	"	276	"
9.39	"	. .	"	272	"
9.40	"	. .	"	"	"
9.41	"	. .	"	"	"
9.42	"	. .	"	"	"
9.43	"	. .	"	"	"
9.44	"	. .	"	"	"
9.45	"	. .	"	"	"
9.46	"	. .	"	"	"
9.50	"	. .	"	"	"

A third time the pressure is stationary, only it has fallen but 19 atmospheres in 15 minutes. Previously it fell 54 atmospheres during the same time. I open the cock; a small quantity of liquid escapes, but almost immediately gas alone. The change is so apparent that it was noticed by more than twenty spectators at the same moment.

The mist produced by the expansion of the gas is very perceptible, but the general appearance of the jet is entirely modified, and no one would mistake these two successive phases.

From this moment the manometer remains stationary when the cock is shut. It remains so after every closing.

9 52 P. M.	Pressure	225	atmospheres.
9.53 "	"	225	"
New jet of gas—			
9.54 P. M.	Pressure	190	"
9.55 "	"	190	"
Gaseous jet—			
9.56 P. M.	Pressure	143	"
9.57 "	"	143	"
Longer gaseous jet—			
9.54 P. M.	Pressure	72	"
9.55 "	"	72	"
Last gaseous jet—			
9.56 P. M.	Pressure	0	"

The experiment is finished. The flask is removed while still hot, so as to prevent the plug from binding. The mouth is closed with a cork, and it is left to cool; when cold water is poured into the interior, until its level reaches the copper joint to which the screw-plug was attached. This water evidently occupies the same volume filled by the oxygen during the experiment.

The weight of the water poured into the flask is known accurately by twice weighing the receptacle in which it was. Weigh it before filling and after—the difference corresponds to the weight of water poured off. This weight was exactly 944 grammes; the volume is consequently 944 cubic centimetres.

Another observation also recorded during the experiment was the pressure, *P*, corresponding to the vacuum formed by the carbonic acid pumps, so as to determine the temperature at which liquefaction takes place. These observations were repeated several times, and the results agree so completely for all the experiments, that the averages are absolutely exact.

We will here particularize a minor point, which, however, is of importance for the determination of the temperature of the flask during the operation.

So as to avoid all danger of explosion, should an unforseen accident occur, I surrounded the flask with three large cast-iron rings placed one on the other. They form a sort of thick sheathing, 50 centimetres in height, of 23 cm. interior diameter, and 32·5 cm. exterior diameter.

There is a clear annular space of about 3 cm. between the flask, which is in the centre, and the inside of this sheathing, and through which the gas flames can circulate.

This arrangement allows the flask to heat very evenly; and when the temperature is high enough to cause chemical reaction, has the special advantage of retaining this heat a long time without great variation.

The external radiation cannot have any influence on the flask, only on the sheathing, whose enormous mass represents a sufficient quantity of heat stored up.

We have searched all the most reliable authorities for the necessary data to determine this very high temperature.

Judging from the softening of glass; from the temperatures which produce a dull red color; from the fusion of metals; from the use of an air thermometer; it can be assumed that this temperature is between 480° and 500°; a temperature of 525° would be a maximum, and 480° would be too low.

The gas flame having been extinguished since the reaction was finished, the temperature remains about stationary during the following half-hour. We will assume it at 485° in our calculations; basing this assumption on the fact that our experiments have lasted sufficiently long to give to this lower figure a greater degree of exactitude than to the higher one. In this respect an error of 20 degrees is admissible, and has but a slight influence on the numerical result.

Of the five experiments made to liquefy oxygen, three were made with carbonic acid and two with protoxyde of nitrogen.

These experiments took place:

1st. Monday, Dec. 24, from 9 A. M. to 1 P. M., with carbonic acid.

2d. Thursday, Dec. 27, from 10 A. M. to 12, with carbonic acid.

3d. Thursday, Dec. 27, from 8 A. M. to 10 P. M., with carbonic acid.

4th. Saturday, Dec. 29, from 4 to 6 P. M., protox. nitrogen.

5th. Friday, Jan. 4, from 4 to 6 P. M., protox. nitrogen.

As already stated, we do not intend giving all the data, *in extenso*, to hours and minutes, relating to these experiments, but will group in the following table the essential results which characterize the phenomena of liquefaction, and which serve as a basis for calculations.

In every experiment, we have introduced into the flask exactly the same quantity of chlorate of potassa mixed with chloride of potassium.

These chemicals, prepared with the greatest care in the chemical laboratory of Prof. Mounier, have been dried, melted, then bruised before being placed in the recipient. The quantities I used in these five experiments were:

Chlorate of potassa,	700 grammes,
Chloride of potassium,	300 "

The most important observations refer to five successive phases in each experiment. We will specify them:

1st. The maximum pressure observed on the manometer after all the gas has been liberated, and after condensation has taken place in the tube."

This pressure is stationary during one-quarter of an hour at least. It is always less than the pressure recorded by the manometer at the end of the extremely rapid chemical reaction.

2d. "The pressure after the first jet," when it is "*distinctly*" observed that the liquid jet is replaced by a gaseous one.

Close the cock and record the pressure instantly.

3d. "The stationary pressure which follows the constantly diminishing pressure during this last operation."

The condensation of oxygen in the tube causes this fall of pressure.

When the tube is filled a second time, condensation is suddenly interrupted, and the pressure becomes stationary.

4th. "The pressure after the second jet."

5th. "The stationary pressure after the second jet."

In none of our experiments has the third jet been complete; it was always perceptibly shorter than the first two, which proves that condensation could not have been sufficiently abundant to fill the chilled tube three times.

We shall see in the following chapter how these numerical data can give us the density of the liquid oxygen.

Here is the table of the five experiments which we designate by numbers 1 to 5 at the head of the corresponding column.

The pressures are corrected for the error of the manometer, and represent the effective tensions.

TABLE OF THE NUMERICAL RESULTS OBTAINED DURING FIVE CONSECUTIVE EXPERIMENTS ON THE LIQUEFACTION OF OXYGEN.

NOTABLE PRESSURES.	PRESSURES GIVEN IN ATMOSPHERES.				
No. of Experiment, ...	1.	2.	3.	4.	5.
1. Maximum stationary pressure of oxygen before first jet issues, ...	470	471	471	469	469
2. Pressure indicated immediately after first liquid jet, . .	367	395	432	400	416
3. Stationary pressure before second liquid jet, lasting several minutes, ...	308	339	378	346	361
4. Pressure after second jet, .	285	290	291	285	296
5. Stationary pressure before third liquid jet, ...	274	271	272	251	253
6. Pressure immediately after third jet, which is of very short duration, ...	. . .	245	. . .	215	205
7. Stationary pressure reached about five minutes after third jet,	. . .	253	. . .	218	212
8. Pressure after fourth jet, which is still gaseous, ...	0	0	0	0	0

In the following chapter we will make use of the numerical results contained in this table, to calculate the density of liquid oxygen by two different methods.

(To be continued.)

THE SINGING TELEPHONE AT THE STEVENS INSTITUTE OF TECHNOLOGY.

By Henry Morton, Ph. D., President.

A number of experiments have been made at the Stevens Institute of Technology with telephones for singing and for speaking, which, while not of a nature to form a systematic research, have, nevertheless, developed facts of sufficient interest to merit some record. These experiments were chiefly conducted during the summer holidays, by several students and graduates connected with the Institute, under the general direction of the present writer, and were carried on, in the first place, mainly with the view of developing a loud-sounding instrument to transmit musical tones, and thus fitted for use in illustrating public lectures on the subject.

The gentlemen concerned in these experiments were Messrs. Wm. E. Geyer, Henry A. Beckmeyer, and Brown Ayres.

The point of departure was the oldest form of the singing telephone, described by Reiss in 1863, and consisting of a transmitting and a receiving instrument. This transmitter, used by Reiss, consisted of a mouthpiece like that of an ordinary speaking tube, connected with a box or chamber, one surface of which was provided with a large round aperture covered with a parchment diaphragm. To the centre of this diaphragm was attached a small plate of platinum, with a metallic connection, to a binding-post. Opposite this central point of the diaphragm was supported a screw, with a platinum point, adjustable so as to touch the platinum plate on the diaphragm lightly when at rest. On singing into the mouthpiece the diaphragm was made to vibrate in unison with the note, and thus a corresponding intermittent current was transmitted to the receiving instrument.

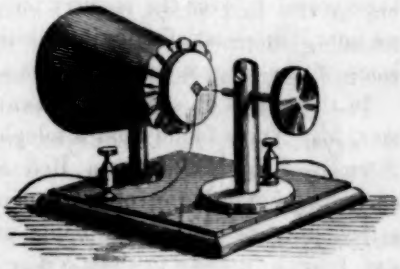
The receiving instrument employed by Reiss consisted, at first, of a simple electro-magnet mounted on a resonant case, the sounds produced being simply due to the molecular changes in the soft iron bar of said magnet. Afterwards he used an electro-magnet, with a

movable armature, whose vibrations then became the source of the sound.

The transmitting instrument employed by us (shown in Fig. 1) was made in the shops of Messrs. Geo. Wale & Co., located in our building, and consisted of a truncated hollow brass cone, provided with a ring slipping over its smaller end, by means of which a diaphragm of thin sheet rubber could be readily attached. To the centre of this diaphragm was attached a small circular piece of platinum foil, to which was soldered a very fine copper wire, which led to a binding-screw upon the base-board of the instrument. Opposite the diaphragm was a screw, with platinum point, supported on a brass column, so as to touch lightly the platinum foil in the centre of the diaphragm. The base of this column was also provided with a binding-screw, to carry on the connection.

This apparatus being connected with a battery, it is evident that on singing into the cone, vibrations corresponding to the note would occur in the diaphragm, and these would, in turn, cause ruptures and renewals of contact corresponding, in frequency, between the platinum foil on the diaphragm and the point of the opposing wire.

Fig. 1.



This was, in effect, nothing more than the transmitter of Reiss, made more compact and adjustable.

After numerous experiments with other plans, which operated with greater or less success, the following arrangement was made by Mr. Geyer, with much better results than any we had obtained before. An ordinary U-shaped electro-magnet, about three inches long, wound with coarse wire, so as to have only about two ohms resistance, was supported with its limbs vertical and the ends of its poles turned upwards. On each pole was laid a narrow thread of soft india-rubber. Upon these again rested an ordinary armature cemented to the resonant case of an Æolian harp.

The intermittent current here produced vibrations by fluctuations in the attraction between the magnet and armature, the necessary

resilient force being supplied by the lines of rubber on the face of the magnet. With this instrument the sound produced was loud enough to be heard over a large room.

For greater convenience, however, the magnet was supported in a horizontal position, thin rubber bands, such as are used for filing papers, being stretched on it, so as to cross the face of each pole. The armature was attached to the bridge of a guitar, which, in its turn, was hung from an upright stand, so as to have the armature rest against the poles of the magnet.

This gave to the whole apparatus an elegant appearance, and produced a very striking effect in its use, as the guitar could be hung on its support without any special care or adjustment, and would then immediately begin to sound out the tune which was being transmitted from the other end of the line.

Such an instrument was fitted up for a concert troupe, who have been traveling over the country for some months past, and has given, we hear, entire satisfaction, exhibitions having been made with it in some of the largest concert rooms and other public buildings.

In the course of some experiments which he made during the summer, Mr. Ayres found that a telephone—made after the pattern of those used by Mr. Graham Bell at his lectures in New York last spring, and consisting of a permanent magnet with soft iron pins attached to its poles, these being surrounded with coils of fine wire, and having opposite to them a disc of sheet-iron about six inches in diameter—made an unexpectedly good receiver for a current transmitted by such a Reiss transmitter as we have described.

An application of this was soon made to what we may call the "guitar receiver," see Fig. 2, by Mr. Beckmeyer, who, securing the guitar firmly in an erect position, brought a large permanent U magnet, with soft iron pins and fine wire coils, very close to the armature which was attached to the guitar.

The instrument, so arranged, was found to give a louder sound, and to operate more easily than the previous one. The battery used in all these experiments consisted of six Leclanché cells of the usual kind supplied by the Leclanché Battery Company, 40 West 18th Street, N. Y.

It struck the present writer as a very remarkable circumstance, that effects so nearly alike should be obtained under such different

conditions as were here present. Thus, in what may be distinguished as Mr. Geyer's telephone, the resistance of the magnet was only about 3 ohms; while in what we may call Mr. Beckmeyer's arrangement, it was about 200 ohms.

A series of experiments, carried on at his suggestion, also showed that the excellence of effect in loudness and range of tone did not depend upon the mere strength of the magnetic attraction, but might be greatest when that was least, and that the suppression of the extra current by the use of a condenser seriously impaired the effect of the apparatus.

FIG. 2.

This seemed to indicate that currents of high intensity, such as the extra current or an induced current, might be of special efficiency.

Such, indeed, proved to be the case. The battery current, interrupted by the transmitter, was passed through the primary of a small induction coil, and the secondary circuit of the same was then connected with the line in which the guitar receiver was placed.

Under these circumstances the results obtained were very excellent, the sounds produced being quite as loud as those from the battery current.

There was also another advantage in this arrangement, namely, that lines of very high resistance could be interposed, and thus the induced current could pass, for example, through the bodies of several persons and yet produce loud music in the guitar. This makes a very striking lecture illustration or experiment.

Though reached independently by the course of reasoning and experiment here noted, no claim of originality is made in this connection, for one of Mr. E. Gray's patents covers the use of an induced current with an electro-magnet and armature attached to a sounding-board.

A further practical improvement was made in the transmitter at the suggestion of Mr. Ayres, by substituting thick letter paper for the sheet-rubber diaphragm.

This greatly increased the range of action of this part of the apparatus, and thus facilitated its adjustment, and made the certainty of its action on all occasions much greater.

Another matter of practical importance was seen to be a convenient and portable battery, sufficiently constant to operate the apparatus for the time of ordinary experiments, without unnecessary bulk and weight. To meet this requirement, the present writer designed the following arrangement which was constructed for him, and is now regularly manufactured by Messrs. Geo. Wale & Co.

Ten glass specimen tubes, 1¼ by 4 inches, in other words, large test tubes, flat at the bottom and with heavy glass rings at the top, are set in holes bored in a strip of wood secured against a flat piece of thin board, 8 by 12 inches. At the upper part of this board are attached two staples of brass, into which drop the ends of a bar of wood. On the bar are fastened, by a single screw each, seven rectangular pieces of sheet brass. Each one of these, except the terminal one, holds, by simple pressure, a wire connected with an element of carbon or zinc on either side. These elements dip appropriately in the tubes. The terminal plates of brass hold only one wire each, and close the end connections by contact with the staples, each of which has a binding-screw in its lower part.

A very cheap, compact, and yet efficient, battery is thus produced. For exciting fluid, a strong solution of Glauber salt will answer very well, so will one of sal-ammoniac; both of these are entirely non-corrosive and harmless if spilled. Dilute sulphuric acid produces more energetic effects, but even the neutral solutions will produce all the force necessary to fill the largest lecture room with sound from the guitar.

A NEW METHOD OF GRINDING GLASS SPECULA.

By Prof. Elihu Thomson.

The use of glass in the construction of specula for telescopes has almost superseded that of metal. The many advantages arising from the employment of silvered glass specula are well known, many fine mirrors constructed of this material being in existence.

The principal expense to amateurs and others desiring to construct for themselves a serviceable speculum arises from the preparation of metal-grinding tools. These, usually two in number, are generally made of brass or cast-iron, carefully turned and scraped to approximate curves, and finally ground together until the desired accuracy of surface is obtained.

This operation of fitting requires the use of special appliances, and is at once a tedious and difficult operation to the unpracticed. The tools, prepared as stated, are employed to give form to the glass which is to constitute the reflector.

The obvious difficulties of preparing metal-grinding tools of large size; the impossibility of avoiding conditions of strain in cast metal, and the greater expansion by heat of the metal tool than of the glass to be worked, make it desirable to avoid the use of metal-grinders where practicable. This is particularly the case where but one or two specula of any given focal length are to be prepared.

It is believed that the method presently to be described provides a means of obtaining a good figure at the same time that the metal tools are completely dispensed with, and from the simplicity of the process any one who can give the requisite care demanded by all work of the kind, may practice it with success.

The principle of the method is, the fact that when two equal discs of glass or other material are ground together, one above the other, the under one always becomes convex while the upper one becomes concave, and, by making the strokes of the upper disc wide and sweeping, this change of form may be greatly accelerated.

The reason for this is obvious; when the upper disc *A*, Fig. 1, is in the position there shown, the downward pressure is principally upon the edge of the lower disc and upon the centre of the upper

one, thereby causing a greater action of the interposed grinding material upon those parts, so that there eventually results a form similar to Fig. 2. The strokes may be so made that the surfaces in contact become spherical, this condition being greatly favored by the fact of the material of the two discs having the same relative hardness, elasticity and expansion by accidental changes of temperature during the grinding operation.

By testing, from time to time, the curve acquired by the discs, any desired radius may be obtained.

Where a spherometer is not at hand, simply using the wet concave in the sun and noticing at what distance from the centre of the disc the reflected rays give the best defined image, we are enabled to obtain the focal length at any stage of the process. Where solar light is not available, the rays of a lamp may obviously be used to obtain the data for calculating the focal length.

The details of the process are as follows: The grinding material is, of course, emery of various degrees of fineness, the polishing being accomplished with rouge or ferric oxide, prepared either by

Fig. 1

Fig. 2.

heating pure ferrous sulphate to decomposition, or by heating precipitated ferric hydrate to a bright red.

For details, as to preparation of emeries, precautions to be taken, methods of testing surfaces obtained, etc., we refer to Dr. Draper's very able paper on "Silvered Glass Specula," in the Smithsonian Contributions, Vol. XIV.

Two discs of heavy skylight glass, nearly free from bubbles and other imperfections, are obtained. They should be of a thickness not less than half an inch, for a diameter of four or five inches, and should increase in thickness with increase of diameter. The edges should be circular, rough or sharp edges being removed by grinding. The surfaces should be flat, and parallel to each other.

The disc which is to be the under one during the grinding process, and which we shall designate *B*, is placed upon a grinding-post, Fig. 3, the under surface being equally supported at its various points. The disc is kept in position by pieces of wood, *a*, *a*, *a*, *a*, Fig. 4, placed around it at regular intervals, thus permitting easy removal, if

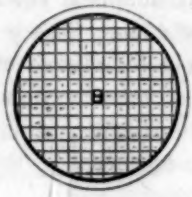
desired. The grinding-post, as is usual, may consist of a barrel, weighted or held firmly to the floor.

Having cemented a handle to the back of the disc which is to become the speculum, and which we shall designate *A*, it is placed upon the disc, *B*, emery, say, No. 60, and water supplied, and ground over *B* with wide, swinging strokes, fresh emery being supplied as needed. This process is continued until the tests of curve above mentioned show that the disc *A* has acquired a surface, the focus of which is somewhat longer, say $\frac{1}{8}$, than the desired focus. The discs are now carefully washed, to get rid of all the coarse emery, and a finer grade, say 90, applied for continuing the grinding. The same operation is repeated, using flour emery, and afterwards the washed grades, which may be, successively, $\frac{1}{2}$ min., 5 min. and 10 min. emeries. Between each grade a careful washing of the hands, discs,

Fig. 3.

Fig. 4.

Fig. 5.



etc., is necessary, to avoid retention of coarse particles that may fall subsequently upon the glass surfaces, and produce scratches difficult to remove. While using the flour emery, the curve can, with proper care, be made to reach that required to produce the desired focus, on attaining which the swing of stroke is to be lessened, to avoid shortening the focus.

The grinding with the very fine grades of emery, seldom produces any considerable change in the focal length, if the proper stroke be given. If, through any cause, too short a focus has been obtained, it can easily be lengthened by reversing the relative positions of the two glass discs, making *A* the lower. To obtain a spherical surface, all possible directions of motion are to be given to the upper disc, and the operator should work from various sides of the grinding-post. It may here be said that the writer has not had the opportunity of applying this method to production of specula, otherwise than by hand. There is little doubt, however, of its success with appropriate machinery.

In the last and final grinding with emery, the greatest care must be exercised, as much time may be saved in the polishing by the attainment of a good surface and figure by the grinding.

In the employment of the finest grade of emery, the last charge should be kept on and worked down so smoothly that no grinding noise is made by the two surfaces sliding one over the other. Just sufficient water should be added to keep the surfaces uniformly wet, an excess being apt to wash off the fine cutting powder so essential to success in this part of the operation. The smoothing is continued until the surface of *A* can reflect the light of a window at incidences of 40° to 50°, and when examined by transmitted light, preferably by using a magnifier, should present *a very fine and uniform grain*. Before making any change in grade of emery, it is essential that all marks made by previous sizes have been obliterated.

If, in the fine grinding, after sufficient examination, the conditions mentioned appear to have been attained, the speculum is ready for the polishing. This is done in the usual manner. The polisher is prepared by coating the lower or convex disc, *B*, with a layer of pitch, or other well-known composition, to about $\frac{1}{8}$ inch thickness, and after having warmed the coated disc so as to soften the pitch, the concave disc, *A*, is wetted and pressed upon the pitch surface of *B*, to ensure a fit.

Parallel grooves are then made in the pitch surface in such a way as to divide it into squares of uniform size, Fig. 5—a well known procedure in polishing specula—after which the surfaces are again carefully fitted as stated above. Preferably, the diameter of the polisher is about one-tenth or one-eighth less than that of the surface to be polished by it, as by this means the desired figure is more readily obtained.

The disc *A*, to be polished, is now laid upon the grinding-post, concave side upward, and the polisher, *B*, charged with finely washed rouge, worked in all directions on it, occasional additions of rouge being made. When the surface of the speculum is sufficiently polished to reflect light, tests of figure are made from time to time, the methods of Draper and Foucalt being admirable for the purpose. The attainment of a spherical surface is in this way free from especial difficulties, and it may be converted subsequently into that of a paraboloid of revolution by the method recommended by Dr. Draper, and fully described in his paper previously referred to.

It cannot be too strongly urged upon those attempting the construction of specula that changes of temperature, by handling or otherwise, must, during the polishing, be carefully avoided. The silvering of the finished speculum is readily accomplished by following closely the method given by Dr. Draper.

Tests of this method of grinding specula, made during the last two years, show that its capabilities are at least equal to those of the usual process with grinding-tools of metal, and it is possible that with increased experience the latter may be surpassed. The method has, however, undoubtedly the advantage of a saving of time in preparation of the tools, as also of expense for materials used.

ON THE DEVELOPMENT OF THE CHEMICAL ARTS, DURING THE LAST TEN YEARS.[i]

By Dr. A. W. Hofmann.

From the *Chemical News*.

[Continued from Vol. lxxv, page 415.]

R. Wagner proposes[ii] to employ in the preparation of nitric acid the hydrated alumina obtained as a by-product in the treatment of cryolite and bauxite. If this is ignited with Chili nitre, nitric and hyponitric acids escape, the latter being utilized by treatment with air and water. The residual aluminate of soda is decomposed with carbonic acid into carbonate of soda and hydrate of alumina, the latter being utilized in the decomposition of fresh quantities of nitre. Instead of the hydrated alumina, Wagner thinks it possible to use finely-divided silica, as obtained on the decomposition of soluble glass or of fluoride of silicium. The method, proposed as early as 1865 by Wagner, has subsequently been twice patented in England, in 1867 by J. Poole, W. Stase, and H. Baker,[iii] and in 1870 by J. H.

[i] "Berichte über die Entwickelung der Chemischen Industrie während des letzten Jahrzehends."

[ii] R. Wagner, *Wagner's Jahresber.*, 1865, 249.

[iii] *Deutsche Industrie Zeitung*, 1867, 158; *Wagner Jahresber.*, 1867, 998.

Johnson.[i] As far as known to the author, this method has not been carried out on the large scale.

Tessié du Motay[ii] proposes to pass a mixture of ammonia and oxygen over manganates, permanganates, and chromates, heated to 340° to 560°, decomposing the nitrates thus formed by air and steam at a red heat, when nitric acid is liberated, and the chromates or manganates are regenerated. Like so many other suggestions of this much-inventing chemist, the process has not come into industrial utilization.

R. Weber[iii] has recently made known a method for obtaining St.-Claire Deville's anhydrous nitric acid easily and in quantity. He adds anhydrous phosphoric acid to the refrigerated monohydrated nitric acid, and distils at a gentle heat. The distillate consists of two non-miscible liquids. The upper stratum is decanted off and cooled below 0°, when crystals of nitric anhydride are formed in abundance. According to Weber's statement, confirmed by Berthelot,[iv] the yield is very satisfactory.

A very sensitive test for nitric acid is sulphate of brucin, which gives an intense red color. On adding stannous chloride a violet precipitate is produced.

According to the statement of C. D. Braun,[v] confirmed by Böttger,[vi] sulphate of aniline is equally sensitive with the brucin salt. A solution of aniline sulphate is prepared by dissolving 10 drops of aniline in 50 c.c. of dilute sulphuric acid (1 : 6). Half a c.c. of this solution is then placed in a watch-glass, mixed with 1 c.c. of concentrated sulphuric acid, and a glass rod moistened with the liquid to be tested is drawn through the margin of the mixture. In presence of nitric acid red stripes appear, and the whole liquid gradually turns to a rose color. If more nitric acid is present the color becomes a deep red-brown, and finally a brownish yellow.

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[i] J. H. Johnson, Specification 2866, October 31, 1870. (The process was tried experimentally in England, about 1850, at the works of Messrs. Metz and Halcrow, Droylsden, near Manchester, but was not considered remunerative.—Ed. *C. N.*)

[ii] *Deutsche Industrie Zeitung*, 1871, 388.

[iii] R. Weber, *Pogg. Ann.*, cxlvii, 113; *Berl. Chem. Gesell.*, 1872, 804.

[iv] Berthelot, *Bull. Soc. Chim.*, 1873; *Ber. Chem. Gesell.*, 1873, 1560.

[v] *Zeit. Anal. Chemie*, 1867, 71; *Wagner's Jahres.*, 1867, 197.

[vi] *Jahresber. Phys. Vereins Frankfurt*, 1866-67, 18; *Wagner's Jahres.*, 1868, 254

According to Reichardt,[i] 1 part of nitre dissolved in 1000 parts of water gives no reaction with the aniline solution, whilst 1 part of nitre in 100,000 parts of water gives a very distinct coloration with brucin.

For the determination of small quantities of nitric acid in potable waters, a great number of methods have been proposed. Recently, F. Tiemann[ii] has made very accurate comparative experiments on the determination of nitric acid in the analysis of water. He arranges all the methods in four classes.

I. Methods which depend on the transformation of the nitric acid into ammonia in an alkaline solution and in presence of a metal. F. Schulze[iii] first based the method upon this principle, and effected the reduction by platinized zinc. Wolf,[iv] Harcourt,[v] and Siewert[vi] employ zinc and iron filings; Bunsen,[vii] a spiral of zinc-iron; and Chapman,[viii] aluminium-foil. In all these cases the ammonia generated is isolated by distillation, and if in large quantity, determined by means of a standard acid, but if in small traces, by means of Nessler's test. According to Frühling's statements,[ix] confirmed by Tiemann, the methods based upon this principle give inaccurate results in presence of organic matter. Finkener[x] observed that all the nitric acid was decomposed, but that in no case was all the nitrogen completely converted into ammonia.

II. Determination of the nitric acid by reduction to nitric oxide and re-conversion into nitric acid. This method, proposed first by Schlösing,[xi] and then modified by Reichardt,[xii] depends on the reduction of nitric acid to nitric oxide by the action of ferrous chloride and hydrochloric acid, oxidation of the nitric oxide to nitric acid by means of oxygen and water, and titration of the acid with a dilute soda solution. Schlösing receives the nitric oxide gas over mercury,

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[i] *Arch. Pharm.* [2], cxlv, 108. *Jahresber. d. Chemie*, 1871, 893.

[ii] *Ber. Chem. Gesell.*, 1873, 1034.

[iii] F. Schulze, *Chem. Centralblatt*, 1861, 657 and 833.

[iv] Wolf, *Chem. Centralblatt*, 1862, 379.

[v] Harcourt, *Chem. Soc. Journ.*, xv, 385.

[vi] Siewert, *Ann. Chem. Pharm.*, cxxv, 293.

[vii] Bunsen, *Zeit. f. Analyt. Chemie*, 1870, 414.

[viii] Chapman, "Sutton's Volumetric Analysis," second edition, 80.

[ix] Frühling, "*Landwith. Versuchsst.*," viii, 473.

[x] Rose, *Anal. Chem.*, sixth edition, ii, 829.

[xi] Schlösing, *Ann. Chim. Phys.* [3], xl, 479: *Journ. Prakt. Chem.*, lxii, 142.

[xii] Reichardt, *Zeit. Anal. Chemie.*, 1870, 24.

whilst Reichardt applies soda-lye, which, according to his experiments, absorbs mere evanescent traces of nitric oxide.

III. Methods which determine nitric acid by measurement of the nitric oxide evolved. Walter Crum,[i] as also Frankland and Armstrong,[ii] decompose the nitrates in a highly concentrated solution by concentrated sulphuric acid, and reduce the liberated acid to nitric oxide by agitation with mercury. Crum measures the nitric oxide in the decomposition-tube, whilst Frankland and Armstrong make use of a gasometric apparatus. Like Schlösing, F. Schulze[iii] decomposes the nitrates with hydrochloric acid and ferrous chloride, and receives the nitric oxide, liberated on the application of heat over moist mercury, determining the quantity by measurement. This method, which, according to Wulfert[iv] and Tiemann, gives very accurate results, has been modified by the latter,[v] who employs soda-lye in place of mercury.

IV. Methods which infer the quantity of nitric acid present from its oxidizing action upon a solution of indigo. Marx[vi] mixes 50 c.c. of the water to be tested, with double its volume of pure sulphuric acid, and adds a dilute solution of indigo to the hot liquid until the color appears green. The effective value of the indigo solution is determined by means of a solution of saltpetre of known strength, the conditions being otherwise exactly alike. Tromsdorf[vii] takes only 25 c.c. of water and 50 c.c. of sulphuric acid; determines approximately the quantity of indigo required by a preliminary experiment, adds this quantity at once, and titrates up to the production of a green color. Goppelsröder,[viii] Van Bemmelen,[ix] Finkener,[x] and Fischer,[xi] have proposed various modifications of the method. According to Tiemann's experiments, the proportions indicated by Tromsdorf are best adapted for practical execution. The determina-

[i] Crum, *Ann. Chem. Pharm.*, lxii, 233.
[ii] Frankland, *Chem. Soc. Journ.* [2], v, 6, 77.
[iii] Schulze, *Zeit. f. Analyt. Chemie*, 1870, 401.
[iv] Wulfert, *Dissert. T. Phil. Fac.*, Rostock.
[v] Tiemann, *Ber. Chem. Gesell.*, 1873, 1041.
[vi] Marx, *Zeit. für Annal. Chem.*, 1868, p. 412.
[vii] Tromsdorf, *Ibid.*, 1870, p. 171.
[viii] Goppelsröder, *Ibid.*, 1870, p. 1.
[ix] Van Bemmelen, *Ibid.*, 1872, p. 136.
[x] Rose, *Anal. Chemie*, ii, p. 831.
[xi] Fischer, *Journ. f. Prak. Chemie*, 1873, p. 57.

tion of nitric acid by means of indigo always yields, however, inaccurate results if the water under examination contains large proportions of organic matter readily oxidizable. The prejudicial effect of such constituents may be partially, though not completely, removed by previously treating the water with permanganate.

Nitric acid is employed in many branches of industry. The manufacture of coal-tar colors requires nitric acid for the preparation of nitro-benzol, binitro-benzol and nitro-toluol, from which, as is well known, the various aniline dyes of commerce are elaborated; for the separation of phosphin (chrysanilin) from magenta residues; for the oxidation of anthracen to anthraquinon; for nitrising naphthalin and phenylic alcohol. The conversion of arsenious into arsenic acid is in most establishments effected by means of nitric acid. Large quantities of nitric acid are also employed in the manufacture of sulphuric acid, of nitro-glycerine, of gun-cotton, of silver nitrate, and for the preparation of hare- and rabbit-hairs for the use of hatters.

On the Practical Utilization of Nitrous Oxide Gas. By Dr. OSCAR LIEBREICH, Professor of Medicine in the University of Berlin.

Whilst scientific chemistry in its ceaseless activity produces new substances in rapid succession, and by the charm of this fruitful energy continually acquires creative disciples, we recognize the strange phenomena that medicine tests in a very deliberate manner these substances, each of which exerts upon the animal economy an influence, even though not invariably capable of useful application. The want of good methods, the exceeding difficulty of deciding upon the benefit produced, especially since it is necessary in the human subject to contend with great idiosyncrasies in different individuals, explain this phenomenon. Thus it occurs that bodies which have long been known to the chemist under various points of view, suddenly acquire an increased signification when their utility has been proved in another department. This occurrence is rarer in technology than in medical science. One of the bodies which have acquired a new interest by some practical application is nitrous oxide. No longer a mere laboratory product, it is now, like other medicinal agents, prepared on the large scale.

Nitrous oxide is formed in many reactions. It is a product of the treatment of granulated zinc with nitric acid, or by adding the same acid to a hydrochloric solution of stannous oxide. On the large

scale, however, the only method used for obtaining the gas is the application of heat to the nitrate of ammonia. As absolute purity is required for medical purposes, the use of a pure salt is important. The kind obtained by neutralizing pure carbonate of ammonia with pure nitric acid should be free from chlorine and from sulphuric acid. The well-known reactions with nitrate of silver and chloride of barium show the purity of the materials to be employed. The development of the gas begins at 170°. The chief art in the manufacture consists in the regulation of the heat, which must be moderated when the liberation of the gas commences. If the charge is overheated, nitrogen and ammonia are formed, as well as nitric oxide, the most dangerous by-product if inhaled. Even the gas obtained from pure materials, and with the utmost care, requires purification, which is best effected by a passage through a set of washing-bottles, charged with sulphate of iron, potassa-lye, and milk of lime. Any nitric oxide formed is destroyed by the sulphate of iron, acids are retained by the potash and carbonic acid; the least dangerous purity is further absorbed by the milk of lime.

The organs of dentistry describe minutely the apparatus required, which possesses for chemists no novelty, since it is the same which has been employed in laboratories for the preparation and purification of the gas. In most cases dentists prepare the gas for themselves, but in Berlin an apothecary, Herr Worf, occupies himself with filling gasometers for dentists.

The compression of the gas for sale must be mentioned as a new and interesting feature. This practice was first carried out in London according to Evans' process. The gas used for compression is prepared as above described, and received in iron bottles (about 40 centimetres long by 15 wide) provided with a strong screw-valve. The largest quantities are prepared in London by the mechanician, J. Orchard, Jr., of Kensington, and Messrs. James Coxeter & Son, of Grafton Street, through whose hands the cylinders are supplied, have had the kindness to communicate certain figures showing the enormous amount of the consumption. There were sold in—

1871,	. . . .	146,211 gallons.
1872,	. . . .	214,478 "
1873,	. . . .	202,252 "

The decrease in the year 1873 is explained by a death during narcosis (*British Journal of Dental Science*, Feb., 1873).

The rapid circulation of this calamity through the press discouraged the public. Whilst in January, 1873, 23,000 gallons were sent out, the sale in the month of February, when this misfortune occurred, fell to 10,900; but it has subsequently increased again in an intensified proportion.

In Germany the compressed gas has been introduced by the well-known firm, Ash & Son, of Broad Street, London. No special establishments for the manufacture of the gas are in Germany.

After the discovery of nitrous oxide by Priestley, in 1776, it was more closely examined, in 1809, by Davy,[1] and its essential properties determined; the compression of the gas to a liquid was, however, first effected by Faraday. Davy observed that the gas, if respired, produced in man a peculiar condition, and this experiment has since been often repeated with confirmatory results. A peculiar excitement appears; the senses disappear at the first inhalations, and a singular drumming is felt in the ears. The body experiences a peculiar sensation of comfort, and the observer recognizes the symptoms of merriment. The name of laughing-gas was therefore given to the gas by Davy, on account of these properties, although in certain rare cases the excitement may pass over from cheerfulness to the opposite state of sadness. On continued respiration complete unconsciousness occurs, and finally death. This power of the gas to produce unconsciousness, discovered by Davy, was not practically utilized till later. In 1844, two years before the introduction of chloroform by Simpson Horace Wells, a practical dentist applied nitrous oxide to himself, the narcosis being conducted by the chemist, Dr. Colton. The new process, however, did not come into extended use prior to 1863. Narcosis for the extraction of teeth was often resorted to by dentists under Colton's superintendence, and in 1867 it came to the knowledge of the celebrated dentist, Evans, of Paris. From this time the scientific utilization of the method must be dated. On March 31st, 1868, the gas was tried by Evans on several patients in the Dental Hospital of London, and by the donation of £100, means were provided for testing the merits and defects of the process. The first report[1] on its results for dental purposes was very satisfac-

[1] Chemische und Physiol. Unters. über das oxydirte Stickgas u. das Attimen in demselben, von Humphrey Davy. Aus d. Eng., 1812–14.

[1] First Report by the Joint Committee of the Odontological Society of Great Britain, and the Committee of Management of the Dental Hospital of London, to

tory, especially as regards a large number of cases conducted by Woodhouse Braine.[1] The gas now came into increasing use also on the Continent.

Various apparatus were required to facilitate the inhalation of the gas. There are simple mouthpieces through which the gas streams, and there are more complicated ones which permit the simultaneous entrance of air. There are also gasometers of special construction for receiving the needful quantity of gas. A large selection of such contrivances may be seen in the establishment of Messrs. Ash & Son.

As regards the application of the gas, it has been ascertained with certainty that the narcosis thus produced can be used only in such cases as require a short insensibility to pain. For dental operations the gas is, therefore, peculiarly suited. For more extensive operations in the cavity of the mouth, it is less to be recommended. With skilful management it is possible greatly to reduce the stage of excitement, or to get at once beyond it. A great advantage, as compared with other anæsthetics, is that a tendency to vomit scarcely ever appears at the first inhalation. The action of the heart is scarcely affected, and after the readmission of air the insensibility of the patient quickly disappears, and the general condition of the system is entirely normal. Attempts have been made to operate with mixtures of nitrous oxide and other narcotics. Thus, C. Sauer (*Vierteljahrs f. Zahnheilkunde*, iv Heft, 1869) has experimented with nitrous oxide and chloroform. An instructive treatise on the use of nitrous oxide gas alone for dentists, has been published by Dr. C. Grohnwald.[2]

Although the practical application of this agent has been found useful, we have but few and insufficient facts towards a scientific explanation of its action. It seems that nitrous oxide does not give up its oxygen for combustion, and does not enter into chemical combination with the red blood-globules, since, as Nawrocki has shown, its absorptive relations for blood and for water are almost identical. On respiration, dyspnœa and asphyxia are produced just as on the inhalation of other indifferent gases, but the sense of suffocation is masked by the peculiarity of the intoxication. We must content ourselves with seeking the explanation of the action of the gas in the

inquire into the value and advantage of the protoxide of nitrogen as an anæsthetic in surgical operations. *Trans. Odont. Soc. of Great Britain*, i, No. 2.

[1] Braine, *loc. cit.*, No. 7.

[2] Grohnwald, "Stickstoffoxydulgas als Anæstheticum." Berlin, 1871.

fact that it suppresses the function of the gangliar apparatus of the brain. Direct action upon the nervous organs of the heart has not been traced. Slight as are these scientific data, they yield valuable indications for its application, which correspond with practical experience. In the first place, the gas must not be inhaled for a long time consecutively; secondly, it is advantageous to mix with it at least one-tenth volume of atmospheric air; the longer the narcosis is required, the more air must be admitted, though the proportion must not exceed quarter volume. Especial attention must be paid to the respiration of the patient. That even with this method of inhalation unfortunate results occur need not surprise us, since from incidents not hitherto explained the use of almost every anæsthetic has demanded its victims. The statistical numbers published testify for its relative safety.

It cannot, however, be denied that the complication of the arrangements required for inhalation is an inducement to seek for new agents suitable for the purposes of dentistry. Thus the author has successfully applied, both in short and protracted operations, ethyliden-chloride, which, according to Hofmann, is abundantly formed as a by-product of the formation of chloral from alcohol. It has also been found suitable for dental operations by C. Sauer, of Berlin, in a long series of experiments.

[To be continued.]

NOTES ON SOME POINTS IN BOILER-MAKING.[1]

By Robert Briggs, C. E.

The recent inspection, by the writer, of a proposed standard drawing of a common external fired tubular boiler, such as now has so general usage in this country, brought to notice two errors of construction in general, almost universal, practice, which it may be of some avail to discuss. In the example referred to, there was shown a flat-headed steam dome, with stays, to strengthen it, running down to the sides of the dome diagonally. The steam pipe was taken off from the middle of this flat dome sheet. Now it may be admitted that the staying of sheet, which was three feet in diameter, was ample for the pressure proposed to be carried, so that the conditions

[1] From the *Polytechnic Review*.

for *use* of the boiler were abundantly fulfilled; but it is contended that equal strength could have been had by giving the proper form to the head sheet without staying at all. Thus it is perfectly well known that the strength of a spherical shell, or of any portion of a spherical shell, is twice as great as that of the shell of a cylinder of the same diameter, when both shell and cylinder have the same thickness; or, on the other hand, that a spherical shell, or part of a spherical shell, possesses the same strength as a cylindric shell of the same thickness, when the radius of the spherical surface is equal to the diameter of the cylindric one. In this last case, when the rule stated is applied to the head of the dome or end of the boiler, which head is *formed* to a part of a spherical surface whose radius is the diameter of the dome or boiler, the head or end is "dished" out 0·134 time the diameter of the head or end. A three-foot heat requires to be *dished* only 0·4 of a foot (about $4\frac{3}{16}$ inches) in order to give the same strength to resist internal pressure, for both head and shell, of the same thickness of iron. A little allowance is needed for the thinning of the sheet iron in *dishing* in such case, as it may be thought proper that the thickness be preserved to the equality with that of the shell. This allowance is easily computed. The surface of the flat circular plate is, to that of the dished plate, as 1 to 1·072. That is, the thickness of the circle, before dishing, should be about 7 per cent. greater than that of the iron of the shell. This extra thickness, however, is a refinement of the boiler-maker or user, who would sell or buy the cheapest boiler consistent with full requirements for strength; as the flanging of the head will inevitably upset the flange itself to a thickness much above the original one, so that a dished head, as above described, of iron of ordinary shell thickness, will be much stronger than the shell sheets at the joints, where they are weakened by the rivet holes, even with the double-riveted longitudinal seams.

These considerations apply more particularly to boiler-making in America, where it would be difficult to procure iron so poor that it would not dish readily without impairment of strength, such iron being capable of flanging at any heat; yet the same reasoning applies to English boiler work; although the frequent use of egg-end boilers seems to indicate that the argument here advanced has not been entertained or appreciated. In this country, certainly, it is pure waste of money to make a flat stayed head, when a dished one will answer.

The next point to be noticed is the use of cast iron bonnet manhole rings on the cylindric portion of a boiler when a manhole is wanted on such a surface. First, within some reasonable limit of curvature, it can be affirmed that a bent manhole is just as good for service as a flat one. For shells of $3\frac{1}{2}$ feet in diameter and above, this is absolutely true. Double clips are always better than one; but with one clip, it is practicable to make as good a joint as any steam engineer may desire with such bent manholes, and a rubber, or, what I prefer, a hemp-plait gasket filled with red and white lead (with a little litharge if in a hurry). Secondly, for all places, both curved and flat, a wrought iron manhole ring is better than a cast iron one. It is safer, easier to make up to the boiler, and when the difference of weight is considered, it is nearly, if not quite, as cheap as a cast iron ring piece. Care should be taken to make the wrought iron rings heavy enough. Most of the failures to use them have been occasioned by *saving* in material; but material enough to give strength to the boiler, where it has been weakened by the manhole, is ample for all purposes, and the dimensions to supply this strength are easily computed. Suppose the manhole be 10×14, and imagine a shell $\frac{7}{16}$ thick. The weak place of such a hole is the 14 inch way, if it is longitudinal to the cylinder. There have then been removed from the shell $14 \times \frac{7}{16}$ or $6\frac{1}{8}$ square inches of material, whence, for bare strength only $3\frac{7}{16}$ square inches of iron should be found at each end of the manhole. $2\frac{1}{2} \times 1\frac{1}{4}$ give $3\frac{1}{8}$ square inches of section, and adding to the width $\frac{3}{4}$ for the rivet-holes in the ring, this ring becomes $3\frac{1}{4} \times 1\frac{1}{4}$. This dimension is the least that should be used in this case, and it will be found ample for the jointing of the manhole plate. Little deduction should be made in case the hole is made transverse to the shell. Here the curvature of the shell begins to tell on the strength of the ring, and in such case double clips should be used for the plate.

Wrought iron manhole rings should always be riveted to the inside of the boiler.

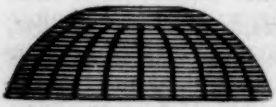
If a cast iron bonnet, manhole ring, or flange boss, is to be riveted to a boiler, it is very desirable to have heavy flanges; quite twice as heavy as usual for flange joints with bolts, and then it is advisable to rivet a thin plate $\frac{1}{8}$ or $\frac{3}{16}$ thick between the casting and the shell of the boiler, so as to form a calking strip to drive against; but in these days of cheap wrought iron, cast iron attachments to boilers, either nozzles, bonnets or rings, have become almost inexcusable

cheapenings. Boiler-makers will also find out, at some time, that wrought iron flue doors, and even fire and ash-pit doors, properly made on formers, are handsomer, more durable, and nearly as cheap, as the ponderous castings which have heretofore disfigured fire fronts.

KENNEDY'S SPRING PISTON.[1]

This invention consists of a cup of brass, or other suitable metal, of the form shown in Fig. 1, and of somewhat larger diameter than the bore of the cylinder in which it is to work. The sides of the cup being slotted, form a series of springs having the outer ends free, but connected at the inner ends.

Fig. 1.



This spring cup is placed within the ordinary leather cup packing, Fig. 2, and together are secured to the piston rod by means of a shield casting and nut, seen in Fig. 3. The complete piston, Fig. 4, being inserted in the cylinder, the springs press against the leather packing, holding it firmly against the walls of the cylinder, preventing it from crimping or folding, as is often the case in the old form of piston.

Fig. 2.

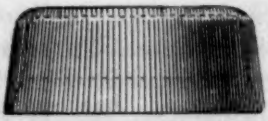
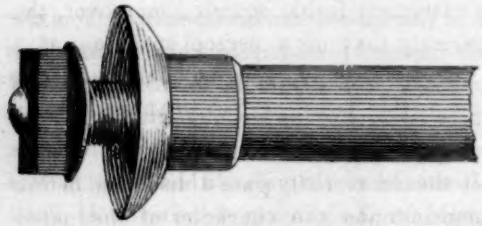


Fig. 3.



This form of piston also has the advantage of adjusting itself to considerable imperfections in the bore of the cylinder, arising from wear or from dents, where the cylinder is formed of sheet metal, as in garden syringes, etc. It is obvious that the piston may be put on the rod either side up, adapting it to either lifting or forcing single-acting pumps, or to double-acting pumps, by placing two such pistons back to back on the same rod.

Fig. 4.

It also seems especially adapted to pumps that are only used at considerable intervals, as the springs prevent the leather from shrinking away from the pump cylinder when it becomes dry, and which would cause troubles when the pump is started again.

[1] Presented at the meeting of the Franklin Institute, May 15th, 1878.

Magnetic Iron.—Donati Tomasi passes a vapor current, under a pressure of five or six atmospheres, through a copper tube of two or three millimetres diameter. The tube is rolled spirally around a small iron cylinder, which becomes so strongly magnetic that a steel needle placed at some centimetres distance is powerfully attracted. The magnetism continues as long as the vapor current is maintained. —*Les Mondes.* C.

Maiche's Diaphragm.—L. Maiche proposes to correct the timbre of the telephone in the following manner: "I stretch before the magnetized bar a caoutchouc membrane, not exceeding four centimetres in diameter, with a thickness of one millimetre. To the centre of this membrane I glue a disc of tinned iron of at least the same thickness, having a diameter of three centimetres, and I cut the caoutchouc, on the side towards the magnet, over a diameter a little greater than that of the magnet. The caoutchouc being well stretched, it can be placed at less than one millimetre from the magnet. I thus combine two seemingly opposite conditions: 1, a thickness of iron sufficient to react properly upon the magnet, and to develop currents of sufficient intensity; 2, a vibratory sensibility which enables me to collect extremely feeble sounds; moreover, the voice which is heard is precisely that of a person speaking at a distance of a few metres. The timbre undergoes no change, all the gradations being preserved in the most perfect manner."—*Les Mondes.* C.

Official Paper.—Prof. Reuleaux recently gave a discourse before a commercial meeting at Leipsic, upon the character of the paper employed in the public offices, which he regarded as a striking evidence that the giving of contracts to the lowest bidder exerts an injurious influence. The paper which is now delivered consists almost entirely of wood, and in the course of ten or fifteen years we may reasonably anticipate that the official records, which are of the greatest importance to our families, will be destroyed through the natural processes of decay. Such a serious evil would seem almost incredible if it was not sustained by weighty evidence. But as long as our officials hold to their present course, and so long as they buy only what is cheapest, and what, as a necessary consequence, is also bad, we have no right to anticipate any improvement.—*Pap. Zeit.*

C.

Niello.—The composition of the Russian tula, or Niello silver, has been hitherto kept secret. According to the *Berliner Tagblatt*, the firm of F. Zacher & Co., in Berlin, have discovered the method of manufacture, and have made it in large quantities. It consists of nine parts silver, one part copper, one part lead, and one part bismuth, which are melted together and saturated with sulphur. This mixture produces the gorgeous blue which has often been erroneously spoken of as steel blue. C.

Internal Magnetism.—M. J. M. Gaugain, from experiments upon steel tubes and nuclei, concludes that the changes of magnetism which are produced, under the influence of heat, in a solid steel bar, do not differ from those which are produced, under the same influence, in a system composed of a tube and a nucleus. Both seem to depend on the inverse magnetism developed by the mutual reaction of consecutive layers, either of the bar or of the system.—*Comptes Rendus.* C.

Dimensions of Lightning-Rods.—Dr. Nippoldt, in a note from the Paris Observatory, objects to the dimensions proposed by Kuhn. Designating by W the heat developed in the rod, I the intensity of the current, r the specific resistance of the conductor, l its length, g its section, s its density, w the specific heat, M the mass, t the temperature, he deduces, by electro-dynamic laws, the equations:

$$t = \frac{W}{t g s w} = \frac{I^2 r}{g^2 3 w}.$$

The temperature is, therefore, independent of the length of the conductor. The metals commonly used are the following:

	w.	s.	r.
Iron, . . .	·1138	7·75	·0986
Copper, . .	·0951	8·95	·0162
Lead, . . .	·0314	11·35	·0199
Platinum, . .	·0324	21·54	·0918

If we adopt 144 square millimetres as the proper section for an iron rod, copper would require 90 sq. mm.; lead, 320; platinum, 156. In these estimates the copper is supposed to be absolutely pure. According to Matthiessen, the pressure of $\frac{1}{2}$ per cent. of iron trebles the resistance. C.

Formation of Whirlwinds.—In Hebert's recent communications to the French Academy, he has laid special stress upon the influence of the land configurations, and especially of the mountains and valleys, upon the great movements of the atmosphere. He comes to the conclusion that all the cyclones which visit Europe from the Atlantic Ocean originate in the American mountains. Many years ago, Professor Henry indicated the region of the Saskatchawan as a prominent cradle of storms. More recent communications to the American Philosophical Society, based partly upon the observations of the Signal Service Bureau, and partly upon special meteorological records at San Francisco and at Barbadoes, have shown that there are two other important centres of extensive atmospheric disturbance: one in the neighborhood of Colorado, and another in the West India Islands. C.

Transmission of Power.—At a late meeting of the Société Francaise de Physique, M. Cadiat explained a method by which he had succeeded in transmitting the movement of a steam engine to a distance of 150 metres, by coupling two Gramme machines, the second being made to turn by the current which is produced by the first. C.

New Telephone Diaphragm.—Louis Ollivier, of Elbeuf, believes that the flat form of the receiving diaphragm interferes with the proper reproduction of the vocal *timbre*. This timbre is produced by the more or less complete blending of different harmonics. Helmholz, by the aid of his resonators, has been able to isolate, successively, the fundamental tone and the different harmonics. After having thus analyzed the sounds, he has recombined them by synthesis. In order to have a diaphragm which may vibrate in unison with various harmonics, Ollivier uses a concave plate of varying thickness, imitating, in some respects, the tympanum of the ear. —*La Nature*. C.

Homogeneous Cast Steel.—The discussions of Gautier and Euverte, upon the influence of silicium in iron, have led to a special investigation by F. Osann, who finds that a very small quantity of silicium offers the best protection against the undue oxidation of the carbon, and the consequent undesirable production of gas and blisters, which interfere with the solidity and homogeneity of steel. —*Zeits. des Ver. Deutsch. Ing.* C.

Darien Canal.—Guzzi and Ravizza invite the special attention of Italian engineers to the proposed American inter-oceanic canal, on account of the increasing prospective importance of Italian commerce. They give an excellent summary of pamphlets, which have been published in France, Italy and America, and of the different propositions which have been made for traversing the Isthmus.—*Il Politecnico.* C.

Electric Meteorology.—In the Atti della R. Accad. di Napoli for 1877, Palmieri gives a *resumé* of his twenty-seven years' observations upon atmospheric electricity, and a description of his principal instruments of observation. By means of simultaneous observations at the University Observatory and at Capodimonte at Naples, as well as at the observatory on Vesuvius, and by comparisons with observations on the Little St. Bernard and in Moncalieri, he finds that in dry, clear air, where the distribution of positive atmospheric electricity is normal, the strength of the influence diminishes with increasing height. This result is different from that which has been obtained by other observers, which he explains by stating that comparisons should not be made between conductors of different lengths, but that similar conductors and instruments should be watched simultaneously at different heights. C.

Daily Barometric Variations.—Renou thus explains the normal daily variations of the barometer. The sun warms the atmosphere which turns beneath it, producing a disturbance over an entire great circle, of which the hottest point is the pole. This effect ceases soon after the maximum temperature, about 4 P. M., producing a maximum pressure at points 90° distant, corresponding respectively to 10 A. M. and 10 P. M. The atmospheric wave which produces this effect follows the apparent movement of the sun with a velocity of 464 metres per second, at the equator. The direction of this wave should produce a greater maximum in the morning than in the evening, and it should also be affected by the easterly or westerly direction of the winds. The night minimum is merely a relative minimum, comprised between the morning and evening maxima. The barometric mean at 4 A. M. should then differ but little from the mean of the whole day. It is, however, some fractions of a millimetre lower, in consequence of the loss of weight from the deposition of dew.—*Comptes Rendus.* C.

Interference of Electric Explosions.—De Waha has found that the interference rings of electric explosions, when observed under the microscope, seldom appear single; but the broad interference mark appears to be overlaid with darker linear rings. He, therefore, concludes that every explosion is accompanied by numerous successive partial explosions or partial sparks. A writer in the *Beiblätter*, suggests that these phenomena correspond to the electric oscillations. De Waha measured the interval between two successive sparks, in a single instance, and found it to be about one four-millionth of a second.—*Beibl. Annal. der Phys. u. Chem.* C.

Discharges in Geissler Tubes.—De la Rue and Müller have been investigating the electric discharge in tubes containing rarefied gas. Among other results they find the following: 1. The discharge in rarefied gas does not differ from that which takes place in air or other gases at atmospheric pressure. It is not a current, but a disruptive discharge, the gaseous molecules effecting a transfer of electrization. The gases probably receive two impulses in opposite directions, that which comes from the negative electrode being most continuous. 2. As the pressure diminishes, the electromotive force diminishes at first, and then increases until a pressure is reached which no electromotive force can traverse. 3. All the strata originate at the positive pole. 4. If the electromotive force is uniform, the phenomena depend upon the intensity of the current. 5. A change of intensity often produces a complete change in the color of the strata. 6. By gradually modifying the intensity, many successive phases of stratification may be obtained, alternately fixed and wavering. 7. The heat is greatest in the neighborhood of the strata. In the obscure portions of the tubes there often appears to be a kind of calorific stratification. 8. Even when the strata are immovable, a regular pulsation may be observed in the current, by means of a telephone or an induction coil. But it does not appear that the strata depend upon these intermittences. 9. The current will not traverse a tube closed by a glass partition. Such a tube can only be illuminated by alternate discharges. 10. Changes of intensity and pressure give a great variety of phenomena, but all the effects are constant, and can be reproduced in tubes of the same dimensions under the same circumstances. 11. If the pressure and current are constant, the diameter of the tube influences the character and distinctness of the stratifications.—*Comptes Rendus.* C.

Economical Value of Solar Heat.—In experimenting with his solar heating apparatus, Mouchot has found that the most satisfactory material for mirrors is either silver or brass, covered with a thin layer of silver by galvanizing. The variations of solar intensity in Algiers, between 8 A. M. and 4 P. M., are generally slight. The quantity of heat gathered on a square metre, per minute, varies from 6 to 9·8 calories. A supply of seven calories enables a reflector of a metre square to boil, in less than twelve minutes, a litre of water at 20°, and produces hourly 778 grammes, or 1322 litres, of steam at the normal pressure. These results are only two-thirds as great as he anticipates from larger receivers. He proposes soon to present to the academy a description of his great receiver of twenty-five square metres, which is to be placed in the Universal Exposition.—*Comptes Rendus.* C.

Deterioration of the Tubular Girders of the Britannic Bridge.—In replying to some remarks in the *Standard* of the 18th inst., on this subject, Mr. Edwin Clark writes: "I was in the habit, for many years, of carefully inspecting the bridge, and in 1866, I was officially requested, in conjunction with Mr. Hedworth Lee, the resident engineer of the London and Northwestern Railway Company, to make a very thorough examination, both as regards state of preservation and its deflection. The result is given in a paper read by myself, at the Institution of Civil Engineers, 'On the Durability of Materials,' vol. xxvii, session 1867-68. After describing the constant care with which its preservation had been attended to, and stating that not the slightest increase of deflection could be detected, the following quotation occurs:—'The author does not hesitate to express his firm belief that the total loss from rust of the whole 10,540 tons, of which the bridge consists, has not in twenty years amounted to a single pound weight. If similar care is continued it is impossible to conceive how any practical deterioration can take place in such a structure, even in several centuries.' This is so completely at variance with the singular statement of the gentleman you quote that I can only imagine the tar and sand with which the cells are internally coated, and which is from time to time cleared out, has been mistaken for iron-rust; but the interior of the cells was at that date absolutely free from any trace of oxidation." Mr. W.

Baker, engineer-in-chief of the London and Northwestern Railway, has also written to the same effect.—*The Engineer.* *

The Electric Fuse and Heavy Cannon.—It seems as if we were about to abandon the old method of firing guns on board ship with the lanyard, and to use the electric fuse instead, at any rate, so far as heavy cannon are concerned. For some years past experiments have been carried on in the navy with electric firing, but it is only since we have had to do with very heavy guns, and particularly those in turrets, that this method of discharge has become almost indispensable. To be cooped inside a close iron turret in company with a pair of terrible weapons of 35 or 38 tons, and to experience the full measure of their thunder, is scarcely to be contemplated with indifference; yet this is not the reason, or at least not the principal reason, why the electric current is to be employed in the future instead of the gunner's arm. The real cause is twofold; in the first place it is possible to take better aim by using electricity to do the work; and, secondly, the effect of the shots are more terrible. The simultaneous discharge of three or four projectiles against heavy armor has been found capable of penetrating the latter, when single shots are quite unable to do so. A vibration is set up in the iron plating, it is presumed, and in this condition the armor is more vulnerable. Simultaneous firing is impossible by hand and word of command, in the same way as gunners used to fire broadsides in the old three-decker days. To the ear the thunder of discharge might appear instantaneous, but the effect upon an ironclad is vastly different if a volley is fired by lanyards, or by a flash of electricity. The other reason is more important still. The guns are so close to the water, and the portholes so limited in size, that sighting along the weapons is frequently a matter of difficulty. The operation is much more easily performed by an officer stationed above, either in the rigging, or in the armored tower, with which most of our modern ironclads are fitted. Provided with suitable sights and electric wires which lead down into the batteries, the captain, or other officer of the ship, here has the whole of its armament under his hand. He directs at what angle the gun shall be laid, and watching his opportunity, discharges them simultaneously at the instant he thinks most fit. Situated above the deck he is removed from the bustle and smoke below, and can act with more coolness and judgment, while obviously no time is lost when the critical moment for firing arrives.—*Standard.* *

The Direct Process of Making Wrought-Iron.—The Dupuy process described in the JOURNAL for December, 1877, has been subjected to a test upon a commercial scale, by Messrs. Miller, Metcalf and Parkin of Pittsburg, who, in a letter to the inventor, dated June 7th, last, say:—"After a careful and thorough series of experiments upon the iron produced by your process, we have to report that it produced a fine steel, equal in quality to any of the best standard tool steels in the market, either foreign or American. It must be borne in mind that this iron was produced from the best magnetic ore we know of, charcoal as a deoxidizer.

"We have thus demonstrated the higher capabilities of your process, and, of course, it is safe to say that worse might be done. As you are well aware, our furnace was not adapted to a sure and economical working of your process owing to a defect in form, therefore we did not develop the commercial side of the process, and do not give any estimate of cost, because we feel that our figures would be unjust.

"Our belief is, that for steel of a very high quality your process could be worked economically in competition with the best Swedish irons."

Inextinguishable Signal Lights.—Mr. N. J. Holmes has recently perfected an improved method of producing intermittent inextinguishable signal lights, which is fully described in the *English Mechanic* for May 31st. It consists in generating phosphuretted hydrogen from phosphuret of calcium in a closed vessel under pressure and, by means of an automatic discharging arrangement, obtaining flashing signals of definite duration and at fixed intervals of time.

In one form of apparatus for this purpose, a strong vessel is employed, into which the proper proportion of phosphuret of calcium, enclosed in a suitable receptacle, is inserted through a movable door at the side.

Upon the top of the vessel is secured a cock, the plug of which is rotated by a mechanical movement. This cock is so constructed that in one position of the plug, it opens a direct communication between the interior of the vessel and the air by which the gas may be discharged, and in another position admitting into the vessel a definite quantity of water—each passage being closed when the other is open. Thus, for every discharge of gas, only the equivalent of water is admitted sufficient to develop the next discharge; the frequency and direction of the discharges being regulated by the speed of rotation of the plug of the cock.

Steel and Wrought-Iron Projectiles.—Experiments are to be resumed at Shoeburyness for the purpose of gaining information as to the penetrative power of steel and wrought-iron projectiles and the resistance of specially prepared targets. Some of the results already obtained have produced most unexpected and surprising experiences, the most remarkable being found during a trial of a composite steel and iron target. When fired against the steel face of the target, the projectiles broke up badly, but when the target was reversed the shot not only penetrated the softer wrought-iron, but went clean through the steel as well. This is theoretically accounted for by the supposition that in passing through the wrought-iron the metal of the projectile gets set up into a more compact body, and is therefore better able to endure the shock of the heavier impact. This discovery, if it be a discovery, is to be further investigated, and in order to test it in the opposite direction a steel projectile with a wrought-iron face upon it has been made at the Royal Laboratory Department, Royal Arsenal, Woolwich, and sent to Shoeburyness this week.—*Iron.* *

Engineers' Club of Philadelphia.—At a recent meeting of the Club, Mr. Wm. F. Sellers read an interesting paper on the Kentucky River Bridge of the Cincinnati Southern Railway. The river at this point is about 300 feet wide, and flows in the bottom of a narrow cañon, about 300 feet deep and 1300 feet wide. For numerous reasons a pier in the river was rendered impracticable; so it was decided to use three spans of 375 feet each, supported by abutments on each cliff, two iron piers in the cañon. The fact that the iron piers would vary in height with the temperature while the cliff abutments would not, made it obligatory that the spans should be so hinged as to permit of this vertical motion of the piers without altering the strains in the truss. To accomplish this it was decided to construct the bridge with a central span supported near each end by the piers, the overhanging portions being hinged to the end spans, the shore ends of which were supported by abutments.

The truss is 37½ feet deep, 18 feet wide, and each span divided into 20 panels of 18¾ feet each, and was erected without the use of any false works, which the height of the bridge and swift current of the stream precluded.

At the same meeting, Prof. Wm. D. Marks called attention to an improved form of Marquoi's Scale.[1] *

[1] See JOURNAL OF THE FRANKLIN INSTITUTE, vol. cv, page 418.

Book Notices.

REPORTS AND AWARDS OF THE INTERNATIONAL EXHIBITION, 1876. GROUP IV. Animal and Vegetable Products and the Machinery for their Preparation. 8vo., pp. 324. Price $1.50. J. B. Lippincott & Co.

The first impression produced upon reading the title of this group is that it should have been divided, as it requires an entirely different sort of knowledge to judge of machinery and of its products. This impression is confirmed upon reading the general report, for there is not a word to be found upon the "machinery."

The general report comprises 42 pages, and consists almost entirely of a history of the doings of the judges, together with some account of the sources from whence the exhibit came, but in no case is there a description of methods or processes employed in the preparation of animal or vegetable products.

There is, therefore, very little to be learned from the report that would tend to advance the industrial arts.

An examination of the reports on awards, covering the remaining 280 pages, discloses some of the difficulties of any system of awards which involves the necessity of selecting from the vast number of exhibits in such a group, any limited number to which awards should be made, or even commenting intelligibly upon each exhibit.

Out of 2727 exhibits named, there are 928 of wine alone and 465 of other fermented, distilled and malt liquors, cordials, &c. The result of the effort to make a descriptive comment on each of these results is an almost constant repetition of "good dry pale XX wine;" "very good dry pale XX wine;" "good sweet XX wine;" "excellent dry pale XX wine," &c.

Again, there are 81 exhibits of "coffee," on 40 of which the judges report "of very good quality," and on 13 "of superior quality—(extra) grain of regular size and color—rich in flavor."

Neither here or in the general report is one able to learn in what portion of the globe the best samples were grown.

GROUP V.—Fish and fish products, apparatus of fishing, &c. 8vo., pp. 47, price 25 cents.

The general report covers 23 pages, is well written, being principally a description of the general character of the exhibits, and in some cases, especially class 642 (pickled fish and parts of fish used for food), a discussion of the exhibits by nationalities.

In this class, France fully maintains the pre-eminence she has so long enjoyed, and exhibits from her manufactures "were rightly considered as standards of excellence."

The exhibits from Norway were very prominent in this class, almost every edible fish caught on the coast of "that country" was found.

The exhibits made by Portugal were of the most varied character, in fact exceeding in quantity that of any other country.

A comparison of the exhibits show that the kinds of fish preserved in the United States, are very few compared to other countries, but but whether this fact arises from prejudice or ignorance, the judges were unable to determine.

Descriptions are given of the American method of preparing canned salmon, and of preparing sardines in France, which, while short, are very instructive.

THEORY OF TRANSVERSE STRAINS, AND ITS APPLICATION IN THE CONSTRUCTION OF BUILDINGS. By R. G. Hatfield, Architect. John Wiley & Sons, New York. Price $6.00. On sale by Claxton, Remsen & Haffelfinger.

This work, from the pen of the author of the "American House Carpenter," is intended to meet the wants of two distinct classes; in the first place, it is for those architects who desire to use better and more exact methods than those furnished by mere precedent, or simple guess-work, but have not had time or opportunity to acquire the requisite knowledge, and secondly, it is for students of architecture, and they will probably find in it an invaluable text-book.

The author does not presuppose any very great previous knowledge on the part of his reader, but beginning at first principles, he makes his formulæ and substantiates his conclusions by simple algebraic demonstrations, combining with them the results of experiments made by himself and others. His method has been, as he says in his preface, "To present an idea at first in its concrete form, and then to lead the mind gradually to the absolute truth, upon which the idea is based," while to enhance the value of the work as a text-book, each chapter is followed by a series of "Questions for practice," or practical examples, which will tend to fix, as well as to make more real and tangible in the mind of the student, the principles and proofs set forth in the preceding pages.

The work seems eminently practical, and considers, in turn, beams and girders of various forms and materials, discussing also the problem of solid wooden floors, suggested as offering more resistance to the spread of flames, and giving co-efficients for the strengths of different kinds of timber, derived from the author's own experiments.

Graphical representation is also made use of, and several chapters are devoted to the graphical expression of strains of various sorts, simple and compound, in levers and beams. Numerous valuable tables are given, which, together with a very complete index and a list of answers to the problems offered for solution, form the last 124 pages of the 630, which the work comprises.

These tables alone, if they are founded on reliable data, will make the book one of great value; nothing is more useful to the practical man than good tables which give at a glance, or without elaborate calculation, the facts for which he seeks.

S., JR.